JUNE 26-28 2018
PAVIA - ITALY

3rd EMAW
PAVIA 2018

3RD EUROPEAN MANTLE WORKSHOP
ABSTRACT BOOK

THIRD EUROPEAN MANTLE WORKSHOP (EMAW 2018)

The third edition of the European Mantle Workshop (EMAW) after Ferrara (Italy) and Wroclaw (Poland) was held in the historical buildings of the University of Pavia, Italy. The meeting consisted of three days of oral/poster presentations, from 26 to 28 June 2018, and 3 optional field trips. The workshop was organized by Department of Earth and Environmental Sciences (University of Pavia) and Institute of Geosciences and Earth Resources of the National Research Council of Italy (IGG-CNR, Pavia), in collaboration with the Italian Society of Mineralogy and Petrology (SIMP). A total of 131 participants, from 22 countries all over the world, attended the workshop.

EMAW 2018 comprised 53 oral and 72 poster presentations, which covered a framework of advanced knowledge on the evolution of the Earth's mantle. The main topics included: (i) mineralogical, petrological and geochemical studies of mantle xenoliths, orogenic peridotites and ophiolitic mantle sections, (ii) experimental studies about production, migration and emplacement of mantle melts and fluids, (iii) geophysical studies and numerical models of the deep mantle, and (iv) serpentinization and carbonation of peridotites, and relationships with microbiology in extreme environments. Keynote talks were given by Françoise Chalot-Prat (University of Lorraine), Sandro Conticelli (University of Florence), Istvan Kovacs (Hungarian Academy of Sciences), Andreas Stracke (University of Münster) and Andrea Tommasi (University of Montpellier II).

Three optional field trips were organized. The one-day, pre-conference excursions illustrated the: (i) Rifting-related structures in the mantle section from the External Ligurian ophiolites (northern Apennine), led by Alessandra Montanini (University of Parma) and Riccardo Tribuzio (University of Pavia), and (ii) Dunite to harzburgite melt conduits in Lanzo South mantle peridotites (western Alps), led by Alessio Sanfilippo (University of Pavia) and Alberto Zanetti (IGG-CNR, Pavia). The two-days, post-conference field trip was aimed at visiting the mantle bodies within and at the base of the lower continental crust of the Ivrea-Verbano Zone, and was led by Antonio Langone (IGG-CNR, Pavia), Maurizio Mazzucchelli (University of Modena and Reggio Emilia) and Alberto Zanetti (IGG-CNR, Pavia).

Field trip guides are available at http://emaw2018iggpavia.unipv.it/. The fourth edition of the European Mantle Workshop will be held in Toulouse, France, in 2021.

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EVOLUTION OF MANTLE MELTS INTRUDING THE LOWER CONTINENTAL CRUST: CONSTRAINTS FROM AN ULTRAMAFIC SEQUENCE OF THE IVREA MAFIC COMPLEX

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We present a preliminary petrological investigation of a 400 m thick peridotite-pyroxenite sequence intruding the lower continental crust of the Ivrea-Verbano Zone (South Alpine domain). This ultramafic sequence is enclosed within gabbronorites of the southern-western sector of the Ivrea Mafic Complex. The peridotites are mostly amphibole-bearing dunites that are locally characterized by poikilitic orthopyroxenes (~1 cm in size). The pyroxenites are also amphibole-bearing and compositionally range from olivine websterites to plagioclase-bearing websterites, with modal orthopyroxene/clinopyroxene ratio >1. Hornblende gabbronorite dykes (up to 15 cm thick) locally crosscut the peridotites and show mm-scale thick, amphibole-bearing orthopyroxenite reaction zones along the contact with host rocks. Peridotites, pyroxenites and gabbronorite dykes typically show nearly polygonal textures, which locally preserve relics of hypidiomorphic magmatic structures. Application of the Ca-in-Opx and Opx-Cpx geothermometers to the peridotites and the olivine websterites gave temperature values ranging from 720 to 810 °C. These estimates reflect slow cooling and recrystallization of the ultramafic sequence in the lower continental crust.

The whole-rock chemical compositions of peridotites, pyroxenites and gabbronorite dykes do not represent frozen melts. In particular, the Mg# $[Mg/(Mg+Fe^{2+})]$ decreases from dunites to pyroxene-bearing peridotites, olivine websterites and plagioclase-bearing websterites, and these Mg# variations are paralleled by olivine, pyroxene and spinel compositions. In addition, the Al content of pyroxene and spinel roughly increases with decreasing Mg#, thereby suggesting formation of the peridotite-pyroxenite sequence in response to a plagioclase-free fractional crystallization process. The following crystallization order could therefore be envisaged for the formation of the peridotite-pyroxenite sequence: (1) olivine, (2) olivine + pyroxene, (3) pyroxene. However, the poikilitic structure of orthopyroxene in the pyroxene-bearing peridotites argues against the stage (2) characterized by coeval crystallization of olivine and orthopyroxene. In addition, the forsterite vs. NiO variations of olivine are not fully consistent with a magmatic evolution controlled by fractional crystallization alone. Hence, the olivine-poor and the olivine-free ultramafic rocks could also form by olivine-consuming melt-dunite reactions, namely reactive migration of the melts feeding the gabbronorite dykes into an olivine-rich matrix. Trace element and isotopic analyses are currently in progress to establish the extents of the fractional crystallization and reactive melt migration processes, and to elucidate the potential process of melt contamination by the gabbronorites hosting the ultramafic sequence.

VARIABLITY OF THERMAL STATE IN THE LANZO MASSIF, WESTERN ALPS, ITALY: ITS IMPLICATIONS ON LITHOSPHERE-ASTHENOSPHERE BOUNDARY PROCESSES

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The lithosphere-asthenosphere boundary (LAB) is fundamental in plate tectonics (e.g., McKenzie and Priestley, 2005). Large and continuous exposure of orogenic peridotite complexes may provide excellent opportunity for direct observation of the LAB zone, from which we may scrutinize large-scale dynamic processes operating there. The Lanzo peridotite massif, exhumed by Alpine orogeny in the early Mesozoic, is divided into three bodies, north, central and south, which are separated by shear zones (Boudier, 1978). Chemical and microstructural heterogeneities have been reported from the massif, and it is proposed that the southern body was originated from asthenosphere and the northern part was sub-continental lithosphere (Bodinier, 1988; Bodinier et al., 1991). This LAB zone model must be assessed in the viewpoint of thermal structure and its temporal change in the Lanzo massif. “Equilibration conditions” have been estimated (e.g., Bodinier et al., 1986), but they must be reappraised in the framework of thermal history. We examined both plagioclase peridotites and mafic rocks collected over the entire massif through petrographic observations and mineral chemical analyses. We confirmed systematic variations of microstructures and mean mineral chemical compositions in the massif, which is consistent with those of previous studies (Bodinier, 1988; Bodinier et al., 1991). We have detected decrease in “frozen temperature” within the massif on the basis of CaO solubility in olivine and pyroxenes as well as Mg-Fe partitioning between olivine and spinel. Chemical heterogeneities of mineral grains were also examined to clarify the significance of “frozen temperature,” which suggest continuous cooling and decompression as suggested by Bodinier et al. (1986). Careful inspection of Ca zoning in orthopyroxene, which better represents a temperature change, shows higher concentration in the grain center and more gradual decrease towards the rim in the south than in the north. In the shear zone, both Ca and Al sharply decrease toward the rim, which may be attributed to mylonitic fine-grained matrix. The same tendency of decreases in “frozen temperature” towards the north, irrespective of geothermometers with contrasting rate of response to temperature change, and the essentially similar cooling and decompression history suggest that the original thermal structure of the LAB zone over tens of kilometers scale was frozen in the Lanzo massif during its exhumation.

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SDEEP MANTEL ROOTS BENEATH ZARNITSA PIPE, RUSSIA

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The Zarnitsa pipe, which discovered in 1954, is the largest in Daldyn region in Yakutian kimberlite province and consists predominantly of grey breccia (Ashchepkov et al., 2018). Black porphyric kimberlites (BPK) are found as separate blocks in quarry, which probably represent older kimberlite magma. They contain fresh olivine and pyroxene grains as well mantle xenoliths consisting of garnet- and spinel- dunites and harzburgites with glimmerite veins containing mica, richterite and Ilmenite. Sheared lherzolites, Cr- bearing websterites with Cr-hornblende and Bi-mineralic eclogites are also present, (Alifirova et al., 2015).

In concentrates, the Cr-rich pyrope (up to 20% Cr2O3) that has dunitic to websteritic affinity, is enriched in TiO2. The trace elements (TRE) show S-patterns (to convex up pyroxenitic) and are enriched in incompatible elements such as U, Th, Nb and Ta. The Cr-diopsides are divided in two groups: the 1st group shows smooth TRE patterns with some variations in HFSE. The 2nd group that is affected by metasomatic processes is Cr- and Na- rich showing highly inclined REE with elevated Nb, Th. The Ti-augites with inclined REE and low incompatible TRE indicate fractionation processes. The Cpx from granulates have negative Eu anomalies, highly inflected REE patterns and low TRE content. The eclogitic omphacites and garnets have negative Eu and HFSE anomalies and the REE patterns show an inflection at Gd. The Cpx from the sheared lherzolites have straight line REE patterns and depressions in HFSE. Garnet REE patterns are round with the top at Gd-Tb. The TRE of the duninic garnets have lower TRE abundances than those from the shated lherzolites and show HFSE troughs.

The mantle structure reconstructed with monomineral thermobarometry (Ashchepkov et al., 2017) shows step geotherm as Udachnaya with high-T pyroxenite lenses at 2.5-1.0 and 4 -5 GPa. The cold dunite lens is located at 5-6 GPa whereas deformed peridotites are detected deeper. Splitting of P- CaO trend into pyroxenite and dunite rays is noted below 5 GPa. High-T ilmenite- Ti augite trend rise from the lithosphere base to 3,5 GPa. High chromium pyropes mainly trace 43-45 mwm-2 to 8 GPa and deeper.

Grant: RFBR 16-05-00860 and Project of Presidium SB RAS № 0330-2016-0010 thanks to FASO.

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DOI:10.19276/plinius.2018.03015

SUBDUCTION-RELATED HYBRIDIZATION OF THE LITHOSPHERIC MANTLE IN MANTLE XENOLITHS FROM TALLANTE (BETIC CORDILLERA, SPAIN)

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Deep seated ultramafic xenoliths provide clues on the nature of the upper mantle giving insight on the nature and composition of sub-continental lithosphere; yet, they are rarely found at convergent plate margins. A notable exception is represented by the Betic Cordillera of southern Spain where the eruption of xenolith-bearing alkaline basalts during Pliocene post-dated the Cenozoic phase of plate convergence and subduction-related magmatism.

In this region the mantle xenoliths, hosted by a pyroclastic deposit of the monogenetic volcano of Tallante, display extreme compositional heterogeneities, plausibly related to multiple tectono-magmatic episodes that affected the area. Mantle xenoliths from Tallante show the occurrence of metasomatised veins of different size and mineralogy witnessing peculiar styles of metasomatism, which induces the crystallisation of quartz (qtz), orthopyroxene (opx), plagioclase (plg), phlogopite (phl), and amphibole (amph), beside the occurrence of several exotic accessory minerals such as apatite, thorite, huttonite, rutile, zircon and graphite. The metasomatic reactions produced different mantle metasomes characterised by "hydrous" opx-rich peridotite, locally crosscut by felsic veinlets. This indicates that the causative agents were hydrous silica-oversaturated melts rich in alkalis, plausibly related to the recycling - via subduction - of continental crust components within the mantle. The present study reports new evidence of suprasubduction metasomatic processes through new detailed major and trace elements and Sr-Nd-Pb analyses of the constituent minerals of composite Tallante xenoliths crosscut by centimetric felsic veins, in order to clarify the mode in which subduction related components are transferred to the mantle wedge in orogenic areas. The final goal is to provide new insights for the genesis of mafic alkaline potassic to ultrapotassic magmas in post-collisional tectonic settings.

GEOCHEMICAL EVOLUTION DURING POLY-PHASE FORMATION OF THE ERRO- TOBBIO TROCTOLITIC BODY (LIGURIAN ALPS, ITALY)

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Many recent studies investigate the replacive formation of hybrid troctolites from mantle-related protoliths and the compositional evolution of the percolating melt during melt-rock interaction processes. However, these processes are often described in settings where the field relationships between protolith and end-product are not available. The Erro-Tobbio impregnated mantle peridotites are primarily associated to a hectometre-size troctolitic body and crosscutting gabbroic dikes, providing a good field control on melt-rock interaction processes and subsequent intrusions. The troctolitic body shows an inner complexity, with a host troctolite (*Troctolite A*) crosscut by a second generation of troctolitic metre-size tabular bodies (*Troctolite B*). *Troctolites A* exhibit two different textural types of olivine, i.e. corroded mm- to cm-size deformed olivine and fine-grained undeformed rounded olivine, both embedded in plagioclase and clinopyroxene. Microstructural features indicate an origin after impregnation of dunites by an olivine- undersaturated MORB-type melt. Mineral compositional trends, e.g. variable An in plagioclase at constant Fo in olivine, are indicative of reactive crystallization and buffering of the melt composition by olivine assimilation during impregnation (*pMELTS*). The *Troctolite B* bodies correspond to brittle-ductile intrusions within the pre-existing *Troctolite A*. They are characterized by extreme textural variations from dm-size dendritic to fine-grained euhedral olivines embedded in plagioclase. We infer that this textural variability is the result of olivine assimilation during formation of the *Troctolite A* (diffuse percolation) and intrusion of the *Troctolite B* (focused percolation), and to the related increase in the degree of undercooling of the percolating melt (increase of the melt liquidus temperature during olivine assimilation). The gabbroic intrusions crosscutting the association between mantle peridotites and the troctolitic body show mineral compositional variations consistent with fractional crystallization of the melts modified after the olivine-dissolving reactive melt percolation related to the formation of the *Troctolite A* and *Troctolite B*. This study highlights multiple origins of troctolites, from replacive to purely magmatic, related to progressive changes of chemistry and style of percolation of MORB-type melts during uplift of the Erro-Tobbio mantle.

MELTING PHASE RELATIONS IN THE EARTH'S DEEP MANTLE: MERGING FIRST PRINCIPLES MINERAL PHYSICS WITH COMPUTATIONAL THERMODYNAMICS

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In recent years, growing geophysical and geochemical evidence has accumulated on the presence of global or local layers of partial melt at the top of the mantle transition zone (Revenaugh and Sipkin, 1994; Bercovici and Karato, 2003; Vinnik and Farra, 2007; Schmandt *et al.*, 2014). Knowledge of melting properties is thus crucial to predict the nature and the fate of melts produced in the Earth's deep mantle. Despite the outstanding progress in computer technology and experimental facilities, understanding melting phase relations at planetary interior conditions is still an open challenge. As a matter of fact, even the most advanced methods to investigate melting display severe limitations that often prevent accurate prediction of phase diagrams and solidus/liquidus phase relations at HP-HT. In this work a novel theoretical framework to predict melting relations by a combination of first principles calculations for solids, polymer chemistry for silicate liquids and computational thermodynamics for solid-melt equilibria is presented and discussed (Belmonte *et al.*, 2017a). This method allows to compute multi-component phase diagrams in a broad range of P-T conditions, that are in turn used as a source of information to gain new insights on the high-pressure melting behavior of MTZ mineral assemblages and provide physically-consistent thermodynamic constraints on both present-day and early Earth melting processes. Application of the above method to binary and ternary systems relevant to the Earth's deep mantle highlights as pressure effects are not only able to change the nature of melting from eutectic to peritectic (and vice versa), but also simplify melting relations by drastically reducing the number of minerals with a primary phase field at HP-HT conditions (Belmonte *et al.*, 2017a,b). It turns out, according to thermodynamic modelling, that Majorite-Pyrope garnet is key to understanding melting relations and solid-state phase transitions in the transition region, provided that its chemico-physical properties are properly assessed (De La Pierre and Belmonte, 2016).

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VARIABLE DEPLETION AND METASOMATISM IN MANTLE XENOLITHS FAR AWAY FROM SUBDUCTION ZONE (TORTUGA HILL, CENTRAL PATAGONIA, ARGENTINA)

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Cerro Tortuga is a volcanic neck located 600 km east from the Chile trench (San Jorge basin, Southern Chubut province) composed by Oligocene-Miocene basalts and gabbros (Sciutto et al. 2008). The basalts carry spinel-facies mantle xenoliths (Villar, 1975), providing insight in the mantle composition and processes.

The mantle column beneath Cerro Tortuga appears fertile as 12 out of 16 studied samples are anhydrous lherzolites, accompanied by subordinate Cpx-bearing harzburgites. They display porphyroclastic and mosaic-porphyroclastic textures in equal proportions. However, the degree of deformation is lower compared to mantle xenoliths from other central Patagonia localities (e.g. Paso de Indios): it resulted in a grain-size reduction of olivine, which locally shows kink-bands. Besides, many samples preserve rounded to stretched clusters made of large Sp and Opx±Cpx, commonly interpreted as the result of Gnt breakdown at spinel-facies condition. Estimated equilibrium temperatures based on Brey & Köhler (1990) and Nimis & Taylor (2010) geothermometers are in good agreement, in the range of 870-960 and 830-940°C, respectively.

The xenoliths define an array in the Cpx/Opx vs. Cpx (Vol.%) diagram consistent with 1 to 25% partial melting of Primitive Mantle. The decrease in modal Cpx is associated with increasing Mg# in all the silicates and decreasing Al in spinel and pyroxenes, as expected after variable degrees of partial melting.

A derivation from partial melting is confirmed for the most fertile lherzolites (Cpx > 10 Vol.%) by the Cpx composition, which is depleted in LILE, Nb, Ta, Th, U and LREE, but enriched in HREE (> 10xCI). The overall REE fractionation is consistent with 4% fractional melting of Primitive Mantle. Conversely, Cpx from Cpx-poor lherzolites (Cpx < 10 Vol.%) and harzburgite show large Th, U, L-MREE and Sr contents pointing to metasomatic interaction with melts extremely enriched in highly incompatible elements. Some harzburgite Cpx have peculiar Zr and Hf enrichments, previously found in rare mantle xenoliths from volcanic arcs (El Fraile; Faccini et al. 2013) and alkaline pyroxenites (Raffone et al. 2009); this is the first evidence of such geochemical feature in the extra-Andean mantle.

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MICRO-CT SCANNING OF GARNET-SPINEL CLUSTERS IN MANTLE PERIDOTITE XENOLITHS

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This study investigates garnet-spinel clusters in mantle xenoliths and forms part of a study of textures related to the transition between the garnet and spinel stability field (Bhanot et al., 2017) which is represented by the reversible equation olivine + garnet = orthopyroxene + clinopyroxene + spinel (Smith, 1977). Studied samples are from Pali-Aike volcanic field, South America and the Vitim basaltic field, Russia.

Micro-CT scans of xenoliths from Vitim and Pali-Aike reveal distinct textures where garnet and spinel exist in close association. Vitim xenoliths show textures forming large elongate structures up to 8mm x 4mm. Garnet grains appear to be clustered rather than evenly distributed. Several garnet grains contain circular spinel structures <4mm in diameter with a weak vermicular texture. Not all spinel within garnet grains is connected and several individual blebs exist within a single garnet grain. Vitim xenoliths display no preferred orientation. Volume of spinel in xenoliths from Pali-Aike is significant and almost all garnet is associated with spinel. Spinel also forms the inner part of the garnet-spinel clusters, forming complex elliptical structures. Spinel displays a vermicular texture with sections in contact with each other throughout the cluster. The size of the cluster is ca. 5mm in length and up to 3mm wide. Garnet forms on the outside of the complex structure but not as a single grain. Several complex garnet and spinel structures display a preferred orientation. A second texture was also observed from Pali-Aike where large evenly distributed garnet grains are more circular. Most of the garnet is spinel-free but several grains have small spinel structures enclosed within the garnet. Thin-sections reveal garnet associated with olivine inclusions. The observed textures in the 3D volumes are examples of the reaction olivine + garnet = orthopyroxene + clinopyroxene + spinel. However, the textures observed in the Vitim samples represent the forward reaction of olivine and garnet brought on by decompression and thus lithospheric thinning, whist the garnet-spinel textures observed in Pali-Aike represent the reverse reaction of pyroxene + spinel brought on by lithospheric cooling and/or compression. The elliptical shape of the both garnet-spinel and spinel-pyroxene clusters coupled with preferred orientation indicate textures are the result of deformation. EBSD analysis will be undertaken to compare and contrast the CPO of pyroxenes inside the clusters with both pyroxenes and olivine outside the clusters.

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MANTLE DOMAINS INTERLAYERED AT CRUSTAL DEPTH: EVIDENCE PROVIDED BY PERIDOTITE XENOLITHS FROM COFRENTES, IBERIAN PENINSULA.

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The Iberian Peninsula is characterized by the outcrops of significant alpine-type pridotite massifs both in the Betic and the Pyrenean orogenic belts, ophiolitic peridote occurrences as well as by several volcanic centres entraining mantle xenoliths (Bodinier and Godard, 2014, Ancochea and Nixon, 1987), allowing a multiple outlook of deep mantle processes occurring in the region.

Mantle xenoliths, such as those from the volcanic districts of Calatrava (central Spain), Olot (south-east Spain) and from the Betic locality of Tallante were extensively investigated by various petrological studies, whereas those of the volcano of Cofrentes have been reported, but so far never investigated in detail. They represent a mantle section located between the Betic and Pyrenean belts, in a sector faulted and deformed at least since the Mesozoic (Villaseñor et al., 2018). The study of these xenoliths is therefore very important to complete the lithospheric mapping of the Iberian region. Xenoliths from Cofrentes are extremely fresh, but rarely exceed 1-2 cm in size. Thin section observation, coupled with in situ-major and trace element analyses, show that they are spinel-bearing peridotite characterized by protogranular textures. Using an iterative method that combines the T-P results calculated with various geothermometers and geobarometers, calibrated for ultramafic systems, we obtained that all samples record equilibration temperatures in the range of 610 to 930 °C, and pressure from 13 to 7 Kbar.

The xenoliths from Cofrentes, if compared with mantle xenoliths from other Iberian localities (and more in general with xenoliths from other volcanic districts of the circum-Mediterranean area studied by our research group) display the lowest equilibration temperatures, thus suggesting a provenance by a mantle domain equilibrated at relatively shallow conditions, as confirmed by the pressure values. Therefore, it appears that the MOHO beneath Cofrentes is shallower than beneath other volcanic districts, and/or that significant slivers of mantle rocks penetrated at crustal level, a process that has to be explained within the geodynamic evolution of the Iberian margin that was affected by multiple extensional and compressional phases.

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VOLATILES IN EARLY ARCHEAN MANTLE, INSIDE GIVEN BY APATITE FROM KOMATII FORMATION (SOUTH AFRICA)

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The problem of water and volatiles origin on the Earth is one of the most important topics under discussion. Furthermore, we still do not know about the water content in early Earth mantle and whether mantle was wet or dry. However, it is widely accepted that late Achean mantle was rich in water (e.g. Ivanic et al. 2015). The best idea how to solve this problem is to trace origin of volatiles with the use of volatiles and water rich minerals that originated on early Earth. The chosen mineral is apatite $Ca_{10}(PO_4)_6(OH,Cl,F)_2$. It can incorporate into the structure volatile ions, such as OH^-, Cl^-, F^- and others. Furthermore, it can appear in various formation environments, including mantle derived ultramafic formations.

One of the oldest formations, in which apatite crystals were altered by secondary processes only partially, is located in the Kaapvaal craton of SE Africa Barberton greenstone belt (3.5–3.2 Ga). Representative samples were collected from ultramafic rocks of Komatii Formation (3.475 Ga). Since analyzed apatites are very old, with a long history of secondary alterations and transformations it is crucial to point out which of investigated apatite crystals preserved primordial signature of the environment of their origin.

Metasomatic processes are thought to have fractionated Cl isotopes toward heavy $\delta^{37}Cl$ values (e.g. Kusebauch et al. 2015a, b). Therefore, chlorine isotopes of representative apatite crystals from Komatii Formation were measured by 1280-HR SIMS instrument. Furthermore, wide range of other scientific methods, such as EMP (Electron microprobe), LA ICP-MS, TEM (Transmission Electron Microscope), Raman and FTIR (Fourier-transform infrared) spectroscopy that provided the information concerning the intrinsic volatile substitution in apatite were used. Furthermore, FTIR allowed us to quantify the structural-incorporated hydroxyl (Wang et al. 2011). Collected data allowed to conclude that at least some of measured apatite crystals could preserved primordial signature of early Archean mantle. Based on the collected data it can be speculated that Earth's mantle was already hydrated on early stage of its evolution (Paleoarchean). Poster presentation will show chlorine isotope data as well as hydrogen content calculations. Moreover, it will discuss the credibility of the collected data and its interpretation in the light of information obtained from other scientific methods.

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MANTLE SUBSOLIDUS AND MELTING BEHAVIOR AS MODELLED IN THE SYSTEM CMASFe.

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Since the pioneering work of O'Hara (1968) much experimental effort has been expended in deducing the mineralogy of the upper mantle and its melting behavior, with the principal aim of understanding the origin of basaltic melts, and the underlying mantle geodynamic processes..

The great majority of mantle peridotite compositions preserve the residual character after multiply episodes of melt extraction through time although many geochemical parameters may be modify by subsequent enrichment process: (*i.e.* re-fertilization and metasomatic processes).

This study, which is based on a simple thermodynamic model, explores a few aspects of mantle subsolidus and melting behavior, following the theoretical melting and drawing the residual compositional trends of both pyroxenes. Major refractory lithophile elements (Ca, Al) and , Mg and Si in peridotite minerals are thus modelled as melting trends in the system CMAS-Fe in the range of 1-3 GPa at various liquidus temperatures (900 -1300 C°). The melting trends are thus modified by subsolidus processes and the residual trends are obtained by solving simple equations based on mass balance and stoichiometric constraints.

None mineral compositions are particularly pressure-sensitive (where there is no garnet or plagioclase to provide a density contrast with other silicates), illustrating the difficulty in finding a suitable barometer for spinel peridotites. The model provides reasonable pressure estimates by P-T-x iterative calculations using available geobarometers. At fixed pressure and temperature the phase relations are invariants, this means that all the phases have a fixed compositions (including Fe^{3+}/Fe^{2+}), irrespective to bulk compositions (Falloon et. al., 2008). This fact has encouraged us to determine the stoichiometry of melting reactions using the experimental data from the CMASF system of Herzberg et al. (2007) and considering Fe as total FeO.

This approach, preliminary in scope and application, provides simple (P)-T-composition relationships that describe mantle phase equilibria and melting in natural occurrences,. This allows the exploration of the subsolidus parameter to disclose the true residual path or pre-existing compositional heterogeneities (melt–rock interaction) of mantle rocks.

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MELT-ROCK INTERACTIONS IN A VEINED MANTLE: PYROXENITE-PERIDOTITE EXPERIMENTS AT 2 GPA

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Interactions between peridotite and pyroxenite-derived melts at deep mantle levels enhance mantle heterogeneity producing hybrid rocks (i.e. refertilized peridotites and secondary-type pyroxenites). The resulting veined mantle has been diffusely invoked as a suitable source of oceanic basalts (e.g. Lambart et al., 2012). We experimentally investigated the reaction between a fertile lherzolite and partial melts produced by a mantle pyroxenite at 2 GPa. Melting behavior of garnet websterite Px-1 (e.g. Sobolev et al., 2007) has been firstly derived. Px-1 starts to melt just below 1280°C, and up to 1350°C it produces MgO-rich basaltic andesites. Garnet and clinopyroxene are progressively consumed by melting (at 1330 and 1380°C, respectively); orthopyroxene is the liquidus phase and is completely exhausted at 1400°C.

We carry out piston cylinder reaction experiments by juxtaposing pyroxenite Px-1 on a powdered fertile lherzolite, previously synthesized at the same P-T conditions of reaction experiments. This allows a direct comparison between the modal and mineral compositions in the fertile lherzolite and in the peridotite modified by reaction with pyroxenite-derived melt. At 1300 and 1350°C, partially molten pyroxenite interacts with the subsolidus lherzolite producing a thin (about 50-100 μm) orthopyroxene-rich reaction zone at the pyroxenite-peridotite interface. Chemical profiles along the capsules show that X_{Mg} in pyroxenes decreases across the pyroxenite-peridotite boundary, with intermediate values in the reaction zone. At 1300°C, residual pyroxenite is more depleted in Fe than after partial melting alone, at the same temperature, and this inhibits the stability of residual garnet. Remarkably, in the subsolidus lherzolite spinel records X_{Mg} and X_{Cr} decrease and TiO_2 increase going toward the molten pyroxenite, with spinel X_{Cr} variation increasing with temperature. Similar chemical gradients are observed in some natural pyroxenite-peridotite sequences.

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NATURAL MINERAL CARBONATION OF SERPENTINITES AND THE INCORPORATION OF ATMOSPHERIC VS. DEEP CO_2

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Mineral carbonation is a process whereby CO_2 reacts with ultramafic rocks to form carbonate minerals such as magnesite ($MgCO_3$) or hydromagnesite ($Mg_5(CO_3)_4(OH)_2 \bullet 4(H_2O)$). This process can be induced artificially at variable pressures and temperatures (from relatively high to low) and therefore has potential to be adapted as a carbon capture and storage (CCS) technology.

Large-scale surface and subsurface carbonate deposits are associated with major faulting across the Italian ophiolites. Here, fractured rock forms a natural fluid pathway and increases the reaction surface for carbonation. CO_2-rich fluids react with serpentinites at different depths and temperatures. Examples of incorporation of deep CO_2 are observed at Malentrata and Castiglioncello (Southern Tuscany, Italy): serpentinites were transformed to a brownish friable rock characterized by the occurrence of opal, chromian montmorillonite, magnesite and minor iron sulfides and oxides. The pervasive alteration of serpentinite was accompanied by the formation of large magnesite–dolomite veins along major tectonic structures, associated with magnesite and dolomite stockworks in the host rock.

At Montecastelli (Southern Tuscany, Italy), present-day interaction of serpentinized dunites with slightly acidic and oxidizing meteoric water, enhances brucite dissolution and leads to precipitation of both Mg-Fe layered double hydroxides (coalingite-pyroaurite, LDHs) and hydrous Mg carbonates (hydromagnesite and nesquehonite). Modern springs in this area, typically discharge alkaline (pH ~8-9) Mg-rich waters, resulting from the interaction with serpentinites.

We use major-trace elements and stable isotopes (O, C, H) to help better interpret the complex geological conditions under which different mineralization formed. At Malentrata and Castiglioncello, the serpentinites chemical composition indicates a strong Si-enrichment and Mg-depletion. About 70% of the original magnesium content was leached and mobilized to the main veins, while the remaining 30% was incorporated into the host rock as carbonate disseminations and veinlets. Trace elements concentration of magnesite is depleted compared to dolomite, suggesting a complex fluid/serpentine interaction and multiple fluid inputs.

At Montecastelli, carbonation is triggered by the rock mineralogy. Reactions in serpentinized dunites containing Fe-rich brucite produce a carbonate assemblage dominated by LDHs and minor amount of hydromagnesite. Serpentinites with a Fe-poor brucite assemblage contain large amounts of hydromagnesite and minor LDHs.

$\delta^{13}C$, $\delta^{18}O$ and δD in these different study-areas span over a wide range of values confirming different genetic processes, i.e., deep CO_2-rich fluid outflow vs continuous rainwater infiltration, water/rock vs water/soil interaction, evidences of evaporation and condensation processes.

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SERPENTINIZATION, METASOMATISM AND MELT IMPREGNATION AT THE ATLANTIS MASSIF (30N, MAR).
NEW STUDIES FROM THE IODP EXPEDITION 357

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During IODP Expedition 357 "Atlantis Massif Serpentinization and Life", an east-west 8.5 km transect across the southern wall of the Atlantis Massif was cored to study the links between serpentinization processes and microbial activity in the shallow subsurface of highly altered ultramafic-mafic sequences that have been uplifted to the seafloor along a major detachment fault zone (Früh-Green et al., 2016). The 57 m of recovered cores show a highly heterogeneous lateral and vertical distribution of ultramafic, mafic, and sedimentary rocks with a range of alteration styles and extent of alteration and deformation. Of the six cores across the southern wall (from west to east: M0071, M0072, M0069, M0076, M0068, M0075), serpentinized ultramafic rocks are predominant (44% by length of core), followed by basalts and metadolerites (24%), schistose metasomatic rocks (11%), calcareous sediment (8%), and gabbros (4%).

The ultramafic rocks are dominated by harzburgites punctuated by intervals of dunite and minor pyroxenite veins; gabbroic rocks occur locally as zones of melt impregnation and veins. Different types of alteration are distinguished depending on protolith: serpentinization, talc-amphibole-chlorite metasomatism and oxidation in the ultramafic rocks; hydration, oxidation, and local Ca-metasomatism/chloritization along contacts between doleritic and gabbroic domains and serpentinites. The sequence of alteration textures and the associated mineralogical assemblages vary between sites and downhole in some cases. Serpentinization is common in the ultramafic rocks at all sites and occurs as pervasive alteration with extensive to complete replacement of the primary mineralogy, forming mesh textures after olivine, bastites (lizardite ± chrysotile) after orthopyroxene, and different generations of serpentine recrystallization and veins. Metasomatism is characterized by varying proportions of talc, chlorite and tremolitic amphibole and is a common feature at the central and eastern sites, evident as pale greenish-white domains or vein networks. Gabbroic intrusions are randomly observed (with a higher frequency in the western cores) and are associated with talc-amphibole-chlorite metasomatism and in some cases chlorite blackwall formation. In addition, REE patterns, grouped by lithology, show a general enrichment in the rocks sampled near the gabbroic intrusions. Our new on-going studies highlight the extremely high heterogeneity of the oceanic crust at slow spreading ridges and point to the important role of the mafic intrusions in controlling fluid chemistry and metasomatism.

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THE CARBON CONTENT OF A MANTLE WEDGE FROM A COLLISIONAL ZONE - THE ULTEN ZONE CASE.

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Although the nature of carbon cycling in convergent margins is reasonably well known, it is recognized that the carbon contents in some lithospheric reservoirs are not well quantified. In particular, the amount of carbon stored in the mantle wedge is essentially unconstrained, with estimates ranging from 0 to 47 Mt/year (Kelemen & Manning, 2015). To help fill this knowledge gap, we carried out a detailed investigation of the Variscan mantle wedge peridotites from the Ulten Zone (NE Italy). These peridotites preserve evidence for fluid-mediated carbon mobilization, followed by storage in a variety of carbonate minerals and partial dissolution during continental collision and subsequent exhumation of the crust-mantle mélange (Förster *et al.*, 2017). A new sampling campaign resulted in more than 150 samples from 13 localities. The new sample set shows that carbon is mainly stored as dolomite occurring in different microstructural sites: included in early spinel, interstitial and dispersed in garnet-amphibole-bearing matrix and in late veins. This testifies to a prolonged carbonation along the entire metasomatic history occurring below 3.0 GPa. Most of the Ulten Zone samples have less than 0.15 wt. % bulk-rock carbon, similar to other bulk data of ultramafics from the nearby Eastern Alps (Melcher *et al.*, 2002). Thus, wedge peridotites are enriched in bulk rock total carbon compared to most of the worldwide xenoliths (bulk carbon below 0.05 wt. %; Deines, 2002). If the results for the Ulten Zone peridotites are representative, the global carbon flux into the shallow mantle wedge can be estimated at 0.01-0.08 Mt C/yr. Many of the considered samples record partial carbon loss by dolomite dissolution and formation of brucite-calcite intergrowths (Förster *et al.*, 2017). This flux is not explicitly taken into account in our calculations, but represented in the bulk carbon concentrations obtained. Nonetheless our estimates are close to the carbon transfer from low-grade subduction mélanges towards the shallow mantle wedge inferred by Kelemen & Manning (2015).

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IN-SITU Re-Os ANALYSES OF SULFIDES IN MANTLE XENOLITHS: NEW CONSTRAINTS ON THE CRATONIC SIGNATURE OF THE VENETO VOLCANIC PROVINCE (NORTH-EAST ITALY)

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The Veneto Volcanic Province (VVP) is one of the widest Cenozoic magmatic districts of the Adria plate. From late Paleocene to early Miocene, the VVP magmatic activity formed the volcanic districts of Val d'Adige, Lessini Mts, Marosticano, Berici Hills, and Euganean Hills. According to literature, magma formation appears to have been triggered by decompression related to the extensional deformation in the South-alpine foreland during the Alpine orogenesis. Most of the volcanic products are relatively undifferentiated lavas, from nephelinites to tholeiites and commonly carry mantle xenoliths. According to previous studies on Val d'Adige and Lessini Mts peridotites, the mantle beneath the VVP exhibits geochemical features typical of off-craton mantle variably affected by Na-alkaline silicate metasomatism (Beccaluva et al., 2001; Macera et al., 2003; Gasperini et al., 2006). However, a newly discovered suite of anhydrous, spinel-bearing mantle peridotites from the Marosticano district exhibit (i) highly refractory compositions comparable with those observed for cratonic peridotites worldwide and (ii) clinopyroxene major and trace element compositions consistent with carbonatite/CO_2-rich silicate metasomatism (Brombin et al., 2018). To test the cratonic signature of the Marosticano mantle domain Re-Os *in-situ* measurements on sulfides and alloys were performed for the first time on VVP mantle domain. The Re-Os model ages (T_{MA}) range between 1.8 and 2.8 Ga, with one at 3.1 ± 0.08 Ga, confirming the derivation of Marosticano peridotites from ancient (cratonic) mantle and also suggesting a "hidden" cratonic signature for Val d'Adige and Lessini Mts lithospheric mantle. These results allow a re-interpretation of the geodynamic evolution of the VVP lithosphere. The Marosticano domain can be interpreted as a vestige of an Archean/Proterozoic cratonic domain, whose signature was not erased by the carbonatite/CO_2-rich silicate metasomatism, whereas the xenoliths from the Lessini Mts and Val d'Adige are remnants of circumcratonic domains compositionally rejuvenated by infiltration of asthenosphere-derived melts. According to González-Jiménez et al. (2013), the VVP Re-Os data enlarge the Archean domain previously recognised within the Alpine domain in the Central Mediterranean area, in contrast with the younger age revealed in the European and African lithosphere.

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ORIGIN OF NON-PERIDOTITIC XENOLITHS AND MEGACRYSTS FROM LOCH ROAG MONCHIQUITE (OUTER HEBRIDES, UK) – PRELIMINARY STUDIES

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A mid-Eocene (Faithfull et al., 2012) monchiquite dyke Loch Roag (Outer Hebrides, Scotland) carries abundant peridotitic, pyroxenitic, mafic and felsic xenoliths as well as megacrysts. The peridotitic xenoliths (spinel lherzolites) are assumed to have a mantle origin (Menzies et al., 1987; Long et al., 1991) whilst the aim of this study is to decipher the origin of the non-peridotitic xenoliths and potential relationships between them.

The studied xenolith suite consists of: anhydrous diorites, biotite-bearing clinopyroxenites, mafic granulites and a K-rich member of "anorthoclasite suite" (Upton et al., 2009). Megacrysts of alkali feldspar are included in this suite. The diorites and clinopyroxenites have cumulate textures. Alkali feldspar megacrysts enclose clino- and/or orthopyroxene, biotite, ilmenite, and apatite. Clinopyroxene in the diorites is Al-diopside (Mg#=75-56), feldspar has composition of An_{40-10}. Clinopyroxene in clinopyroxenites (Mg#=81-66) is an Al, Ti-diopside, Mg# in biotite is 81-68. Granulite is formed of Al-diopside (Mg#-67-62) and plagioclase (An_{45-50}) and garnet altered to fine mixtures of feldspar, spinel and glass. Alkali feldspar megacrysts (Or_{50-95}) have compositions similar to that forming "anorthoclasite" (Or_{80}). The feldspar megacrysts and anborthoclasite xenoliths both contain inclusions of clinopyroxene (Al, Ti diopside, Mg#=60-73) and biotite (Mg#=45).

Clinopyroxenes from diorites, clinopyroxenites and "anorthoclasite" are all LREE enriched, but in the latter the concentration is an order of magnitude lower and lacks the negative Ti, Sr and Zr anomalies of the diorites and clinopyroxenites. K-feldspar forming" anorthoclasite" is significantly lower in trace elements than dioritic plagioclase. Clinopyroxene in the clinopyroxenites and diorites formed at pressures ~from 2.5 to 1.5 GPa and from 1.1 to 0.6 GPa, respetively (Nimis and Ulmer, 1998).

The mafic cumulates are interpreted as products of mafic magmas underplating the lower crust. There is a compositional continuum of minerals from the pyroxene-rich rocks to the diorites suggesting that the latter may be low-pressure differentiates from the mafic magmas. In contrast, the K-felspar-bearing rocks show no affinity with the "pyroxenitic" suite and probably have a distinct genesis.

This study was financed by Polish National Science Centre grant no. UMO-2016/23/B/ST10/01905.

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EXPERIMENTAL INVESTIGATION OF THE INTERACTION OF SALINE FLUIDS WITH THE LITHOSPHERIC MANTLE

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Saline (i.e., Cl-rich) fluids potentially play an important role as metasomatic agents in the lithospheric mantle. Natural evidence for such fluids exists as inclusions within diamonds (Izraeli *et al.*, 2001; Weiss *et al.*, 2015) and within groundmass minerals in kimberlites (Kamenetsky *et al.*, 2004; Abersteiner *et al.*, 2017). Previous experimental studies have investigated melting relations in the chloride-carbonate-silicate system (Safonov *et al.*, 2007), but a systematic experimental study of how saline fluids react with the lithospheric mantle is lacking. Here, we present reaction experiments between a saline fluid and different mantle lithologies (peridotite and eclogite) at conditions corresponding to near the base of the cratonic lithosphere. Experiments were performed at pressures of 3 GPa and temperatures of 1050-1200 °C at the Institute for Mineralogy, WWU Münster, Germany, using a 500 t Walker-type multi-anvil apparatus with a ceramic 18/12 assembly. Starting materials were prepared from powders of high purity oxides, carbonates, hydroxides, and halogen compounds. The fluid mixture was placed at the bottom of the Au-Pd capsule and covered by the mantle rock mixture. Preliminary results show that reactions between saline fluid and lherzolite at 3 GPa and 1200 °C lead to extensive melting in the presence of a free fluid phase. The restite is harzburgitic, consisting mainly of olivine and garnet. Pyroxenes are only observed as rare inclusions within garnet. In contrast, reactions between saline fluid and eclogite at 3 GPa and 1200 °C also lead to melting, but the melt zone contains smaller quench crystals and appears to be more enriched in Si. The restite consists exclusively of garnet. At lower T (1050 °C) abundant phlogopite forms along the contact between eclogite and saline fluid. These preliminary results demonstrate how saline fluids react with different components of the lithospheric mantle.

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TRACE ELEMENT MAPPING OF EXPERIMENTAL SAMPLES WITH LA-ICP-TOFMS

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High-pressure, high-temperature experiments typically produce small sample volumes with small grain sizes. Thus, high spatial resolution analytical techniques are required for their evaluation. High-resolution mapping techniques, e.g., by electron probe microanalysis (EPMA), are especially useful to evaluate reaction experiments with compositional heterogeneities (i.e., reaction zones). However, EPMA mapping is very time-consuming and typically only suited for the detection of major and minor elements. The advent of low-dispersion laser ablation cells with washout times down to tens of milliseconds (e.g., Gundlach-Graham & Günther, 2016) and fast, simultaneous mass spectrometers, e.g., time-of-flight mass spectrometers (e.g., Burger *et al.*, 2017), has paved the way for fast, high-resolution, multi-elemental mapping (e.g., Bussweiler *et al.*, 2017), which enables to visualize the distribution of elements with concentrations down to ppm levels. Here, we present semi-quantitative trace element maps recorded with the technique of LA-ICP-TOFMS on experimental samples by Gervasoni *et al.* (2017). The samples represent reactions between a) hydrous eclogite and peridotite, b) carbonatitic melt and peridotite, and c) kimberlitic melt and peridotite. The maps can be used to infer diffusion and partitioning behavior of different trace elements in experimental samples.

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GEOCHEMISTRY OF EMERGED ULTRAMAFIC MANTLE ROCKS FROM ST. PETER AND ST. PAUL ARCHIPELAGO, EQUATORIAL ATLANTIC, BRAZIL

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The St. Peter and St. Paul archipelago (SPSPA: 0°55'N, 29°38'W) is the emerging tip of the Atoba ultramafic ridge in the Equatorial Atlantic (Maia et al, 2016). It rises over the northern fracture zone of the St. Paul transform system. C-14 ages defined on the Holocene waterline and subtidal deposits from SPSPA and corrected for hydro-isostatic sea-level fluctuations, suggest a steady uplift during the last 6600 years at an average rate of ~1.5 mm/yr (Campos et al, 2010). On a larger time scale, tectonic evidences suggest a sequence of major uplift episodes since >10Ma (Maia et al, 2016). Structural field evidences are in favour of episodic extrusion associated to fault mechanisms as the main agent of emplacement rather than volcanic activity. Local seismicity suggests a dominant strike-slip deformation mechanism even though minor, but still significant, compressional events also occur ($Mb \geq 5.8$) (de Melo & do Nascimento, 2017). The archipelago is mainly composed of highly deformed ultramafic rocks: harzburgite with minor dunite and lherzolite, along with rare kaersutite-rich alkaline ultramafic units. The latter lithology is locally present as mm-scale interlayering within peridotites. All lithologies are pervasively mylonitized and very fine grain size. A late retrograde serpentinization overprinting the peridotite mylonite is recorded at the mesoscopic scale by open system pervasive flow of seawater-dominated hydrothermal fluids accompanied by extensive rock fracturation. Mass-balance calculations of whole rock geochemical data show that the early mylonitization event is nearly isochemical, while some major and trace elements mobilization occurs during serpentinization. Major-trace elements and REE patterns suggest a “mixing” between peridotite mylonite and kaersutite mylonite end-member, similar to the compositional pattern of the immersed rocks around SPSPA region (Brunelli & Seyler, 2010). The Fo %wt versus Mg# contents of orthopyroxene, clinopyroxene, pargasite and spinel show a strong dispersion suggesting that these minerals are not in equilibrium with the coexisting olivine. The olivine (Fo wt%)-spinel (Cr#) pair in the peridotite mylonite from SPSPA plot within the Olivine-Spinel Mantle Array of Arai, 1992 and close to the fertile MORB mantle composition consistently with their primary nature. Spinel composition reveals that the protolith of the peridotite mylonite underwent small degrees of partial melting (~ 5 to 13 wt. %) before deformation.

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MOLYBDNEUM ISOTOPES AS TRACERS OF SEDIMENT RECYCLING INTO THE MANTLE

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Understanding the role of recycled sedimentary material into the convecting mantle represents a key aspect to provide new constraints on the chemical budget of subduction zones. Mo isotopes are perceptive to redox conditions and have been shown to fractionate in the oceanic superficial environment during the incorporation into sediments. The variable composition of Mo isotopes recorded in different geochemical reservoirs offers the opportunity to use these isotopes as tracers of recycled material into the mantle. This is particularly true for sediment formed under anoxic conditions, which inherited from the seawater specifically heavy isotopic compositions. The potassic and ultrapotassic igneous rocks of the Roman Magmatic Province (Italy) show extremely variable and well distinct geochemical and radiogenic isotopic signatures, which are referred to a strong involvement of different subduction-related sedimentary components in their genesis. These magmatic products thus offer the unique opportunity to test the application of Mo stable isotopes to distinguish the contribution of different sedimentary melts/fluids during mantle metasomatism. High-precision Mo isotope measurements were performed on both magmatic rocks and sedimentary end-members. The latter formed at different redox conditions and can be considered as *proxies* of the recycled components. The obtained results indicate that the Roman igneous rocks display variable Mo isotope compositions, which are significantly heavier compared to any sediment-dominated subduction-related magmatic rocks measured so far (e.g., Lesser Antilles). Such heavy isotopic signatures, reveal a sort of “Mo anomaly”, which is not observed in the nearby subduction-related magmatic regions. The heavy isotope composition, along with the pronounced sediment-dominated character, suggests the presence of an isotopically heavy component in the subducted material that is likely to derive from subducted, anoxic organic-rich sediments. In this context, the application of Mo isotopes to complex subduction settings highlights the potential of Mo isotopes as tracers of recycled anoxic sediment, hence the fate of organic carbon, in subduction zones.

KIMBERLITE CARBONATE PETROGENESIS FROM COMBINED COMPOSITIONAL AND C-O-Sr ISOTOPE ANALYSIS: THE BENFONTEIN CASE

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Kimberlites are probes of the mantle melt domains, providing information on mantle composition and structure. However, the composition of their parental melts and their volatile (CO_2 and H_2O) contents are still debated. Primary carbonates in kimberlites trap the CO_2 of the magma and provide insights into the C-O isotopic composition of kimberlite parental melts and their evolution. Here, we combine detailed carbonate petrography of the Benfontein kimberlite sills with *in situ* compositional and isotopic (C-O-Sr) studies to shed light on their petrogenesis. These sills are known for their magmatic-sedimentation features, including oxide-rich layers with abundant primary carbonate, calcite "diapirs" and rare silicate phases. The groundmass calcite of the oxide-rich layers is Sr-Ba-rich and may have a tabular habit. The diapirs of the uppermost part of this layer comprise Sr-Ba-poor rhombohedral calcite and variable amounts of randomly oriented Sr-Ba-rich calcite laths. The upper sill has Sr-Ba-rich groundmass calcite and Mg-Fe-rich secondary veins. The calcite laths in the diapirs have C-O values within the mantle range, overlapping those of the surrounding groundmass calcite. In contrast, rhombohedral calcite in the diapirs has higher $\delta^{18}O$ and slightly lighter $\delta^{13}C$. Both groundmass calcite and the laths in the diapirs have magmatic Sr-isotope values, comparable to primary carbonates in the Kimberley kimberlites. However, the rhombohedral calcite of the diapirs and the secondary calcite veins of the upper sill have higher $^{87}Sr/^{86}Sr$. Our data suggest that the diapirs represent the late intrusion of a low-density, Sr-poor, evolved melt, which trapped some of the Sr-rich calcite laths forming the groundmass of the sills bottom. The isotopic systematics of rhombohedral calcite in the diapirs suggest that this late magma was contaminated by the surrounding Dwyka shales, raising both $^{87}Sr/^{86}Sr$ and $\delta^{18}O$, but decreasing $\delta^{13}C$. Isotopic data (decreasing $\delta^{13}C$ at increasing $\delta^{18}O$) for the groundmass calcite of the upper sill indicate that degassing played a major role in its formation. Intense interaction with shales and hydrothermal overprinting may explain the isotopic values of secondary calcite veins in the upper sill. This work highlights the necessity of *in situ* C-O-Sr isotope analysis for a correct interpretation of carbonate petrogenesis in kimberlites, identifying not only different magma intrusions, but also degassing, contamination and post-emplacement processes.

UPPER MANTLE DIFFERENTIATION CONTROLLED BY PLATE TECTONICSIN THE FRAMEWORK OF THE WESTWARD DRIFT OF LITHOSPHERE: AN ALTERNATIVE OCEANIC PLATE SPREADING MODEL

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Combining geophysical, petrological and structural data on oceanic mantle lithosphere, asthenosphere and basalts, an alternative oceanic plate spreading model (Chalot-Prat et al, 2017) is proposed in the context of the westward drift of lithosphere relative to the underlying asthenosphere (Doglioni et al, 2015). The model suggests that evolution of both the composition and internal structure of oceanic plates and underlying upper mantle strongly depends at all scales on plate kinematics. In return, it emphasizes the fundamental role of natural and experimental mantle petrology to understand their asymmetric features. Indeed geophysical data (seismic velocities, density, thickness, plate geometry) show that lithospheric plates and underlying upper asthenosphere are asymmetric on both sides of oceanic spreading ridges. This asymmetry reflects somewhat different mantle compositions, themselves related to various mantle differentiation processes (incipient to high partial melting, percolation/reaction and refertilization) down to 300 km depth, below and laterally to the ridge axis. The westward ridge migration induces continuing mantle refertilization of the western plate by percolation-reaction with ascending melts, whereas the eastern plate preserves a barely refertilized harzburgitic residue. Plate thickness is controlled by cooling of the asthenospheric residue and by amphibole instability below ~90 km. The intersection of vapour-saturated mantle solidus with the geotherm at ~90 km induces incipient melt production below the lithosphere-asthenosphere boundary and the existence of a low-velocity zone (LVZ). As lithosphere moves westward relative to asthenosphere, the LVZ facilitates the decoupling between lower asthenosphere and lithosphere; also the westward drift of the lithosphere is slowed down, top to down, inducing a decoupling within the lithosphere itself. This intra-mantle decoupling combined with a mantle upwelling at the ridge axis would be at the origin of asymmetric detachment faults allowing mantle exhumation with oceanic core complex formation. The LVZ asymmetry suggests that migration of incipient melt fractions and upwelling paths from the lower asthenosphere through the upper asthenosphere are oblique, upward and eastward. MORB are sourced from an eastward, oblique, near-adiabatic mantle upwelling from an always renewed lower asthenosphere. This unidirectional mantle transfer is induced by isostatic suction of the migrating spreading ridge.

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INFLUENCE OF THE RECYCLED OCEANIC CRUST ON THE INTRAPLATE BASALTS IN SOUTHERN MASSIF CENTRAL, FRANCE: CONSTRAINTS FROM IN-SITU OXYGEN ISOTOPE COMPOSITION AND WATER CONTENT

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There are widespread Cenozoic intraplate basalts with the Mediterranean and surrounding areas, forming the circum-Mediterranean Cenozoic igneous province. Generally, these basalts are characterized with HIMU-like Sr-Nd-Pb isotopic composition. Recently, seismic tomography has demonstrated the presence of the stagnant Alboran and African slabs at 200-300 km depth beneath Western Mediterranean. However, the relationship between the basalts and subducted slabs have been only observed through the D/H analysis of amphibole bearing xenoliths, and remains poorly understood. In this study, we investigated basalts from the Allègre, Mont Coupet, Burzet and Ray Pic in the southern part of the Massif Central, France. We measured the oxygen isotope compositions and water content of clinopyroxene (cpx) phenocrysts using secondary ion mass spectrometry (SIMS) and Fourier transform infrared spectroscopy (FTIR), respectively. The $\delta^{18}O$ (Vienna standard mean ocean water) values of the cpx phenocrysts in basalts (5.5-9.8 ‰) are all obviously higher than normal mantle value (5.4-5.8 ‰). Combined with the high Nb/U and Na/La ratios of the bulk rock, the high $\delta^{18}O$ values indicate that a component of recycled oceanic crust (ROC), which has experienced low -T (<350°C) water alteration, was widely involved in the mantle source of the basalts in Massif Central. The estimated water contents of magma are around 1 wt.% (except for one sample from Mont Coupet), similar to those of the typical OIBs. The H_2O/Ce ratios of basalts (60-246) are slightly lower than HIMU-endmember which may indicate a significant dehydration of ocean crust during recycling. Compared with basalts in eastern China affected by the subducted Pacific slab, the significant differences in oxygen isotope composition and water content suggest a variable degree of alteration and dehydration before and during the subduction process of the involved plates.

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BORON ISOTOPES AND THE ROLE OF SERPENTINITES IN SUBDUCTION ZONES

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Serpentinites carry large volumes of water (~13 wt%) and fluid-mobile elements (e.g. B and Li) into the mantle at subduction zones. Release of these fluids at depth during serpentine breakdown plays an important role in generating arc volcanism and volatile recycling. Boron isotopes are a powerful tracer of this process due to large differences between mantle rock ($\delta^{11}B$ = -7‰), altered oceanic crust ($\delta^{11}B \approx$ -10 to +5‰) and serpentinite ($\delta^{11}B \approx$ +7 to +20‰). However, little is known about the behaviour of B and its isotopes during serpentinite dehydration. Here we report in situ SIMS data (Cameca 1270, calibrated using komatiite glass (for olivine) and serpentine standards) in serpentinites from HP ophiolites from the Alps and Spain, that show high but variable [B] (3.6-16.3 ppm) and $\delta^{11}B$ (+10.5 to +25.3 ‰) in metamorphic olivine formed by breakdown of antigorite ([B] 2.9-17.9 ppm, $\delta^{11}B$ -0.3 to +28.5‰). We present 3 major findings: 1. Most of the metamorphic olivine data shows $[B]_{ol/srp}$ values that are greater than equilibrium values. We demonstrate that this cannot be explained by dehydration processes but only by the addition of excess B from external sources. 2. Those samples that show $[B]_{ol/srp}$ ~ equilibrium values show $\Delta^{11}B_{ol\text{-}srp}$ ~ +12‰, which may represent equilibrium B isotope fractionation at serpentine breakdown conditions. This data can be used in a three-component mixing model to predict the involvement of at least 60% serpentinite to explain the high $\delta^{11}B$ recorded in arc lavas. 3. High B and $\delta^{11}B$ metamorphic olivines in the slab residue raise interesting opportunities for tracing recycling of deeply subducted slabs.

CARBONATED VEINS IN OROGENIC PERIDOTITES FROM THE ULTEN ZONE (EASTERN ALPS, ITALY): INSIGHT INTO CARBON TRANSFER THROUGH THE MANTLE WEDGE

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It is known that carbon is transported from subducted plates and stored into the shallow overlying mantle via fluid-mediated processes (Kelemen & Manning, 2015). Despite that, the C content carried into the mantle wedge is under debate. Mantle-wedge peridotite lenses from the Ulten Zone (Eastern Alps, Italy) record different stages of carbonated silicate melts/COH fluids-related metasomatism and provide an excellent opportunity to study the C transfer in a crust-mantle system at great depths (Förster *et al.*, 2017). A microstructural study combined with chemical analyses of the two main textural types of these peridotites, coarse-grained spinel peridotite and fine-grained garnet-amphibole peridotites, shows different generations of carbonates. In particular in this study, carbonated veinlets crosscutting the peridotite matrix are presented. These veins contain magnesite and/or dolomite that are commonly associated with hydrated minerals. In a coarse-grained garnet-free spinel peridotite, magnesite veinlets are associated with tremolite, antigorite, chlorite and locally with ferroan dolomite (X_{FeCO3}~0.02). The latter occurs in thin veins filling fractures in vein magnesite. This dolomite can be related to an increase of Ca/Mg ratio in the fluid, explained either by magnesite precipitation in a Ca-Mg-rich fluid or by a late supply of Ca2+ ions, after the magnesite formation (Boschi *et al.*, 2009). These processes could have occurred in the magnesite+dolomite stability field, probably around 700 °C and 1.75 GPa. In weakly serpentinized fine-grained garnet-amphibole peridotites, the occurrence of a dolomite vein (X_{FeCO3}~0.02) crosscutting the matrix suggests an influx of C-rich fluids after peak conditions. Late-serpentine veins cut this dolomite, suggesting a subsequent influx of H_2O-rich fluids at T< 700°C. These fluids also induce the breakdown of dolomite, with formation of calcite and brucite aggregates as pseudomorphs after dolomite, and concomitant liberation of CO_2. Furthermore, peridotites were subjected to injection of COH shallow fluids prompting the precipitation of calcite veins that are spatially associated with antigorite and chlorite. In conclusion, the exhumation of the Ulten Zone mantle wedge is coupled with significant infiltration by serpentinizing fluids. These fluids not only enhance de-dolomitization and C release, as expected, but also provide precipitation of vein carbonates that effectively stores a fraction of the slab-derived CO_2.

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RECYCLED CARBONATE SEDIMENTS IN THE METASOMATISM OF CENTRAL MEDITERRANEAN SUB-CONTINENTAL MANTLE AS REVEALED BY MINERALOGICAL, CHEMICAL AND ISOTOPIC CHARACTERISTICS OF POTASSIC MAGMATISM

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Subduction drags a large amount of CO_2 into the Earth's interior, which is partly returned to the atmosphere by arc volcanism. Processes involved in the recycling of subducted carbon within the upper mantle are mainly related to mineralogical transformation during metasomatism. This process can be tracked by the subduction-induced modification of the mantle in term of incompatible trace and major elements (e.g., K, Ca, HFSE), radiogenic and stable isotopes. Potassic and ultrapotassic igneous rocks at destructive plate margin are the result of magmas produced by partial melting of upper mantle that experienced extreme sediment-derived enrichment. The Central Mediterranean, Italian peninsula and surroundings, is the most important region on Earth for studying subduction-related potassic and ultrapotassic magmatism, derived from partial melting of metasomatised lithospheric mantle wedge The erupted magmas display different potassic and ultrapotassic affinity, from leucite-free to leucite-bearing, with associated shoshonites and high-K calc-alkaline. Central Mediterranean potassic and ultrapotassic rocks are extremely enriched in incompatible trace elements with variable fractionation of Ta, Nb, and Ti in comparison to Th and large ion lithophile elements (LILE). They are also variably enriched in radiogenic Sr and Pb and unradiogenic Nd. The main geochemical and isotopic signatures are consistent with sediment recycling within the mantle wedge via subduction. A two-step metasomatism, produced by the recycling of pelitic sediments and dehydration of lawsonite-bearing schists, enriched the mantle wedge from which leucite-free ultrapotassic rocks were generated. The involvement of recycled carbonate-rich pelites played an important role in the shift to leucite-bearing ultrapotassic rocks (kalsilite- and leucite-bearing) of the classic 'Roman province'. Such a process is independently demonstrated by minor element contents of high-Fo olivine from Italian potassic and ultrapotassic rocks, and by whole rock isotope data (U-Th disequilibria, Sr-Nd-Pb isotope, and high-precision $\delta^{238}U$) on historical K-igneous rocks from Mount Vesuvius. The latter requires the addition to the mantle wedge of U-rich carbonated melts, generated by partial melting of subducted calcareous sediments in the presence of residual epidote.These data provide constraints on the deep carbon cycling within Earth.

A GEOCHEMICAL CHARACTERISATION (EMPA AND LAICPMS) OF FINERO PERIDOTITE (SOUTHERN ALPS, ITALY).

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The Finero mantle peridotite (Phlogopite Peridotite unit, Ivrea Verbano Zone, Italy) mainly consists of harzburgites, dunite, subordinate lherzolites and pyroxenites. These rocks ubiquitously possess hydrous minerals, i.e. pargasite and phlogopite, locally in large amount (up to 25 vol.%). According to literature data, Finero peridotites and pyroxenites are characterised by enrichment in Sr, LILE and LREE, but with low HFSE concentrations (e.g. Zanetti et al., 1999). The crystallisation of pargasite and phlogopite, as well as the trace element and the isotopic signature, were interpreted as tracers of pervasive to channelled migration of K-and-Si-rich hydrous melts in a supra-subduction environment (e.g. Hartmann & Wedepohl, 1993; Zanetti et al., 1999, 2016). For these peculiar characteristics, the Finero peridotites have been subject of several works (e.g. Brodie, 1980; Grieco et al., 2001; Morishita et al, 2003, 2007; Selverstone & Sharp, 2011), but a complete geochemical dataset is still lacking. Another peculiar feature of Finero mantle peridotite is the widespread presence of cm- to m-thick ductile shear zones developed at medium/high temperature conditions (e.g. Tommasi et al. 2017 and references therein). Brodie (1980) reported the occurrence of some pronounced chemical trends of minerals and bulk rock as a function of deformation.

The aim of the present work is to provide new geochemical data (major and trace elements of mineral and bulk rock) of the different lithologies, with specific attention to monitor geochemical variations associated with sub-solidus. Major element composition was determined by electron microprobe (EMPA), while trace element abundances were measured via LA-ICP-MS. Analyses were carried out on ten polished thin sections covering most representative lithologies (i.e. harzburgite, dunite, lherzolite, pyroxenitic veins) and deformation textures (from coarse-grained to porphyroclastic to mylonitic) occurring in the Finero peridotite.

Preliminary results suggest that olivine is homogeneous in composition without significant variation in the trace element content, while in other mineral phases (pyroxenes, amphibole and phlogopite) several elements such as Sc, Ti, V, Cr, Mn, Ni, vary considerably among different lithologies. Geochemical changes are related to the modal abundances of the mineral phases; for instance, the Ti, Cr and Zn content within phlogopite is inversely correlated respect to amphibole modal abundance.

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WATER CONTENT IN NOMINALLY ANHYDROUS MINERALS (NAMS) FROM PERIDOTITE BODIES OF THE IVREA-VERBANO ZONE (SOUTHERN ALPS, ITALY).

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One of the peculiarities of the Ivrea-Verbano Zone (IVZ, Southern Alps, Italy) is the presence of several mantle bodies, among which those famous of Finero, Balmuccia and Baldissero, within lower continental crustal rocks. Despite the numerous studies on these mantle lenses, the mechanisms and the geodynamic settings leading to their emplacement into the continental crust are still unknown, even though they are commonly attributed to collisional orogenic systems (Quick et al., 1995).

To place further constraints on the formation and geodynamic evolution of the IVZ sequence, a new investigation on the main mantle bodies is ongoing, by combining the study of the water content in hydroxyl forms (OH) detectable by means of infra-red spectroscopy (FTIR) in the Nominally Anhydrous Minerals (NAMs) to petrographic and geochemical surveys.

Hydrogen is present only as a trace element in NAMs composing the Earth's mantle, but its abundance is believed to have important consequences on fundamental physical properties such as rheology, seismic attenuation and electrical conductivity (Padròn-Navarta et al., 2014, 2017). Although there is a wide literature on hydrogen distribution in NAMs from relatively dry mantle xenoliths, there is a remarkable absence of data on Alpine peridotites. The current investigation aims at filling such a gap and providing important information about the petrological evolution of the mantle sequences, in particular as a consequence of melt-related processes, rheologic and physical properties of subcontinental mantle rocks. Preliminary data for the Finero Phlogopite Peridotite (Ph-Pd) show that i) the olivine water content is around 2 ppm. (according to the calibration of Bell et al. 2003), with only minor variations depending on the lithology and texture, and ii) the water contents in orthopyroxene and clinopyroxene are also comparatively low (respectively around 42 and 137 ppm (Corvò et al. 2017). These values are surprisingly low considering the water-rich nature of the Finero Ph-Pd, which experienced K-rich metasomatism documented by pervasive crystallization of hydrous mineral phases, such as amphibole and phlogopite (up to 25 vol. %).

In order to better understand the role of i) bulk rock and mineral composition and ii) the occurrence of hydrous minerals on the OH budget, the water content in NAMs will be determined for the Balmuccia and Baldissero lherzolitic mantle bodies, which are conversely characterised by weak to absent metasomatism.

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EVOLUTION OF THE LITHOSPHERIC MANTLE UNDERLYING NORTHERN HESSIAN DEPRESSION

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Northern Hessian Depression (NHD) is part of the Rheno-Hercynian Zone in Variscan orogen of Europe. Mantle peridotite xenoliths occur in some of Cenozoic alkaline volcanics of NHD. Our study includes Hirzstein and Baunsberg (outskirts of Kassel) mantle xenolith suites. The xenoliths are protogranular to porphyroclastic harzburgites and lherzolites, composed of olivine (1-7 mm), ortho- and clinopyroxene (up to 4 mm), spinel (up to 2 mm, usually in clusters with clinopyroxene). Groups of 600 μm phlogopite booklets occur in one xenolith. Silicates contain abundant fluid inclusions of various size, locally forming trails.

Forsterite content in olivine defines two groups of xenoliths: A (Fo 89.9-91.4) and B (Fo 87.6-89.3). Group A xenoliths plot into OSMA field of Arai (1994). Pyroxenes are highly magnesian (Mg#=0.90-0.92). Lherzolites contain orthopyroxene with 0.11-0.22 atoms of Al per formula unit (pfu), clinopyroxene with 0.13-0.31 atoms of Al pfu, and spinel with Cr# 0.12-0.32. Harzburgitic orthopyroxene has 0.09-0.15 atoms of Al pfu, clinopyroxene has 0.13-026 atoms of Al pfu, and spinel has Cr# 0.22-0.46. Group B consists of two lherzolites and one harzburgite, containing orthopyroxene Mg# 0.88-0.89 and 0.11-0.22 atoms of Al pfu. Clinopyroxene has Mg# 0.87-0.89 and 0.17-0.31 atoms of Al pfu. Lherzolitic spinel is characterized by Cr# 0.13-0.18, whereas the harzburgitic one ~ 0.50.

Orthopyroxene shows LREE depletion (La/Lu_N=0.12-0.38) and has positive Zr, Hf and Ti anomalies, which are especially well-defined in grains rich in fluid inclusions. Clinopyroxene is LREE enriched (La/Lu_N= 5.54-25.47) and their trace element patterns show strong depletion in Nb, Pb, Ce and slight depletion in Zr, Hf and Ti. The peridotites containing the most magnesian olivine were little affected by metasomatism, whereas those with Fo in olivine <91.0 were affected by various metasomatic agents. Hartmann & Wedepohl (1990) claim that part of NHD mantle was affected by COH fluids, and Mengel et al. (1984) argue, using Sr isotopes, that these fluids acted shortly (<1 Ma) before eruption of host magma. Our observations evidence that the metasomatism preceding volcanism was related to silicate melt. The occurrence of fluid inclusions in large and well recrystallized grains of silicates suggests that the metasomatic fluid event might have been an early event.

Funding: This study originated thanks to the project NCN UMO-2014/15/B/ST10/00095 of Polish National Centre for Science to JP.

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MINERALOGY OF CU-RICH HYDROTHERMALLY ALTERED PYROXENITES IN THE CHESHMEH-BID CHROMITITE DEPOSIT, KHAJEH-JAMALI OPHIOLITIC MASSIFS, IRAN: A FIRST REPORT

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The Khajeh-Jamali ophiolitic massifs (southern Iran) are mainly composed of mantle harzburgite tectonite and dunite, and exposed the Moho transition zone (MTZ), intruded by abundant pyroxenite dykes. In the Cheshmeh-Bid chromitite deposit, few pyroxenite dykes and veins host native copper mineralization. Mineral assemblages of pyroxenites can be divided into primary, secondary, and late phases in origin. The primary assemblage is composed of diopside, enstatite, and Cr-spinel. The secondary assemblage is strongly hydrated and consists of antigorite, Cr-bearing chlorite, tremolite, talc, titanite and native copper. Native Cu occurs along cleavages and partially healed fractures in diopside, and as massive grains intergrown with antigorite. The late mineral assemblage includes fine-grained pseudomorphous intergrowths of lizardite and talc and includes secondary chalcocite. Microprobe data show that the chemistry of diopside and enstatite presents moderate variations among crystals. The Mg# (Mg/(Mg+Fe$_{total}$) of diopsides ranges from 0.90 to 0.98. They are characterized by high CaO contents (21.9–25.8 wt. %) and low Na_2O (<0.79 wt. %). Enstatite has Mg# of 0.89–0.93. It has Cr_2O_3, Al_2O_3 and TiO_2 contents, 0.12–0.46 wt. %, 0.36–1.85 wt. % and <0.05 wt. %, respectively. The Cr-spinels has Cr# [= Cr/(Cr + Al), average~ 0.75) and Mg# [= Mg/(Mg + Fe^{2+}), average~0.73]. Chlorites has low FeO (<1.59-4.67 wt. %), high MgO (27.7-33.6 wt. %) and variable Cr_2O_3 contents (0.07-3.41 wt. %). Amphiboles are characterized by variable concentrations of Cr_2O_3 (0.17-2.22 wt. %), TiO_2 (<0.78 wt. %) and Al_2O_3 (0.26–10.11 wt. %). The preliminary petrographic and mineral chemistry data show that the primary mineral assemblage likely formed in the mantle at high temperature (940°C-1024°C) from Mg-andesite or boninite melts. The secondary mineral assemblage appears to have formed during successive hydrothermal events. During hydrothermal alteration, some magmatic diopside grains have been modified in chemistry, with increasing Mg# (0.95-0.98) and formed newly nucleated crystals. Native Cu formed via highly reduced fluid after the formation of chlorite +tremolite. It is also crucial to mention that Cu-bearing fluid was low in sulfur activity because of the absence of Cu-bearing sulfides. The late mineral assemblage appears to have formed at low temperature under conditions of low silica activity.

CONTEMPORANEOUS EMISSION OF CALC-ALKALINE AND ALKALINE MAGMAS IN SUBDUCTIVE GEODYNAMIC SETTINGS: A MANTLE XENOLITH PERSPECTIVE

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Calc-alkaline (CA) and alkaline (Alk) magmatism generally occur separate in space and time in convergent margins. Alk magmatism usually post-dates the CA event and is generally related to a slab retreatment-induced asthenospheric upwelling and/or to the onset of post-orogenic trans-tensional regimes. Alternatively, the formation of a slab window may also provide access to the rise of deep, fertile mantle material.

Irrespective of the mechanism, how is this succession reflected in the mantle sources? Are the CA and Alk mantle domains intermingled at mantle depth or is it necessary to invoke a “source substitution” occurring in a geologically negligible time span?

Clues to the answer may come from mantle xenoliths abundantly found in pyroclastic deposits from i) the Pliocene-Quaternary Alk volcanic field of the Perşani Mountains (Transylvanian Basin, Romania), whose late eruptions were contemporaneous with the emission of the South Hargita CA magmas in the south-eastern corner of the Carpathian arc, occurred only 9 km afar (Seghedi et al., 2011) and ii) the Alexandra Volcanics in the North Island of New Zealand, where CA and Alk eruptive products are randomly intercalated in the volcanic sequence of the Pliocene-Quaternary Karioi and Pirongia stratovolcanoes (Briggs and McDonough 1990).

The Transylvania ultramafic xenolith suite is mainly composed by fertile, amphibole-bearing lherzolites with geochemical evidences of two main metasomatic events: tholeiitic refertilization followed by percolation of Alk melts similar to the Perşani mildly Alk lavas. The arc affinity of the tholeiitic metasomatic agent may indicate that a substitution of the former mantle source by asthenospheric material in a very short time span (due to a combination of slab retreatment and diapiric uprise in the Transylvanian Basin area, Konečný et al., 2002) was required for the set-up of the subsequent Alk magma genesis.

The Karioi mantle xenoliths are embedded in tuffs, preventing the identification of the geodynamic affinity of the host basalts. These nodules were metasomatized by a CA agent and, so far, no indication of Alk agent was spotted. In this case, the contemporaneous emission of both CA and Alk magmas suggests the presence of different mantle domains with peculiar petrological features below the Alexandra Volcanics area.

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COMMON LINK FOR THE MANTLE SECTION OF OPHIOLITES FROM THE PACIFIC COAST OF MEXICO?

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The mantle section of supra-subduction zone (SSZ) ophiolites often contains chromitites, i.e., rocks consisting mainly of Cr- and Al-rich spinel. In the last decade zircons of crustal origin have been found coexisting in these rocks with typical mantle minerals, raising the interest of geoscientists. In this work we report *in-situ* dating of crustal zircon and coexisting platinum-group minerals in chromitites from the mantle section of two Mexican SSZ ophiolites: the Late Triassic Puerto Nuevo ophiolite (Baja California Sur), and the Late Jurassic to Early Cretaceous Loma Baya ophiolite (Guerrero). Chromitites from Loma Baya are high-Al chromitites [Cr# (Cr/Cr+Al) = 0.49-0.56] with a composition similar to chromitites crystallized from melts with back-arc basin basalt (BABB) affinity. Chromitites from Puerto Nuevo are high-Cr chromitites (Cr# = 0.61–0.69) whose composition resembles those of chromitites that crystallized from melts with high-Mg island-arc tholeiitic (IAT). *In-situ* Re-Os analyses on 12 grains of laurite [$(Ru,Os)S_2$] from the Loma Baya chromitites yielded $^{187}Os/^{188}Os$ ratios at 0.1250–0.1271, which correspond to $T_{MA} \approx T_{RD}$ model ages between 0.14 and 0.45 Ga, and cluster around two peaks: 300 Ma (predominant) and 130 Ma. Re-Os isotopic analyses of laurite-erlichmanite (RuS_2-OsS_2) and osmium alloys grains (n=76) from the Puerto Nuevo chromitites yielded Os isotope compositions with corresponding $T_{MA} \approx T_{RD}$ model ages between 0.16 and 1.13 Ga, and cluster around a single age peak at ~325 Ma. A population of 10 euhedral zircon grains from the latter chromitites yielded concordant or nearly-concordant ages between 278 ± 4 and 310 ± 3 Ma (1σ). The clustering of Os model ages at the 325–300 Ma interval is in accordance with ophiolitic chromitites that formed within a piece of lithospheric mantle that experienced melting during the Carboniferous, thus suggesting their possible formation within common mantle. Zircon ages within the ~325–300 Ma range in the studied chromitites correspond to the magmatic activity that led to the formation of the *ca*. 311–232 Ma continental magmatic arc in western Mexico. We suggest that the mantle portion of these two ophiolites once belonged to the same volume of mantle beneath an intra-oceanic arc, which underwent deep recycling in the mantle and, finally, was exhumed in different regions that experienced intra-arc spreading.

THE GEOMETRY OF INTERSTITIAL PHASES IN OLIVINE-RICH TROCTOLITES: NATURAL ANALOGUES TO EXPERIMENTS

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Olivine-rich troctolites or plagioclase dunites from the Krivaja peridotite massif in Bosnia- Herzegovina consist of 75 - 85% olivine, 15 - 20% plagioclase, up to 3% clinopyroxene and 1 - 2% spinel. Ni contents of olivine have the same range as lherzolites from the massif, with olivine Mg# in the range from 88 to 90. Plagioclase and clinopyroxene are interstitial to olivine, with geometries (triple junctions, larger pockets and wetted grain boundaries) that are also observed in experiments with partially molten dunites. Clinopyroxene is observed to form a thin layer between olivine and plagioclase or is poikilitic, with individual grains enclosing multiple olivine grains. Later crystallizing plagioclase is mostly altered, with only few patches that can be indexed by EBSD. Piston cylinder experiments conducted to simulate cooling and freezing of melt in the plagioclase dunites show similar microstructural features, for example retreat of early crystallizing pyroxene from grain boundaries, with rounded tips. EBSD mapping of whole thin sections reveals a crystallographic preferred orientation (CPO) with [001] maximum in the foliation plane, which is identified from a weak shape preferred orientation of olivine. The observed texture with indistinct [100] and [010] patterns does not correspond to texture types observed in deformation experiments both under melt-free or melt-bearing conditions. EBSD maps of samples from layered intrusions show a CPO consistent with crystal settling, distinct from the CPO of the plagioclase dunites. Olivine in the plagioclase dunites shows essentially no grain internal deformation, confirming that the observed CPO was not produced by deformation. The microstructures and CPO may originate during infiltration of fertile and highly deformed lherzolites beneath an incipient rift by a pyroxene-undersaturated melt that dissolved all of the original pyroxene and enabled extensive recrystallisation and grain growth of olivine. The lack of observable deformation features indicates that melt infiltration occurred in static environment. The similarity of natural and experimentally observed 'melt' geometries suggests that experimental microstructures and physical property measurements can be applied to natural rocks with substantially larger grain sizes.

RETRIEVING TIMESCALES OF CRUSTAL EVOLUTION AND MANTLE DYNAMICS FROM DIFFUSION PROFILES: THE CASE OF ATLANTIS MASSIF (IODP SITE U1309D, MAR 30°N)

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Recent studies of primitive olivine-rich lithologies from slow-spreading oceanic crust reveal that portions of the upwelling mantle are locally assimilated, and thus participate to the building of the oceanic crust. The poikilitic textures and heterogeneous modal-geochemical compositions of olivine-rich troctolites (Ol-T) from IODP Hole U1309D (Atlantis Massif [AM], Mid-Atlantic Ridge 30°N) were interpreted as marking local assimilation of mantle into the gabbroic sequence, during a period of enhanced magmatism. Melt-rock interactions were triggered by percolation of primitive MORBs, but their timescales have never been modeled and remain uncertain. Our aim is to clarify the timescales of (i) mantle-melt interactions and (ii) cooling of the gabbroic sequence forming the oceanic crust at IODP Site U1309D. We intend to understand the dynamics of mantle emplacement and assimilation into the oceanic crust at AM. For this, we first realized geochemical traverses along olivine (ol) and adjacent clinopyroxene (cpx), then we used numerical diffusion models to reproduce the measured profiles. Ol represent relicts of pre-existing mantle ol, while cpx and plg are the crystallizing product of melt-rock interactions. Compositions of ol are in equilibrium with those of poikilitic cpx. Ol geochemical profiles are flat for all major and trace elements with the exception of Ca, Y and HREE (e.g., Yb), which show lower concentrations at rim compared to those at respective ol cores ('bell shape' profiles). Flat profiles point to complete re-equilibration of ol during the magmatic reactive event. Three-dimensional diffusion models show that, at T = 1250-1300°C and P = 2 kbar, 100% ol re-equilibrates in 18 to 375 years for major and minor elements and Y, and in less than 200 ka for REE. The Ca-Y-HREE 'bell shape' profiles suggest diffusive re-equilibration during cooling of the U1309D gabbroic sequence. One-dimensional diffusion models indicate that the closure of the cooling system was attained within 450 years. Based upon diffusive numerical modeling of ol-cpx geochemical profiles, the fast ol re-equilibration occurred within the time of emplacement (~200ka) of the gabbroic sequence at the AM. This suggests that mantle assimilation took place while it was progressively exposed by the detachment fault, during enhanced magmatism in a cooling system. The decrease of temperature recorded by Ca, Y and HREE suggests that reactions occurred at shallow depths at the mid-ocean ridge.

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HIGH-PRESSURE RELICS WITHIN A MANTLE BODY ENCLOSED IN THE MIDDLE CONTINENTAL CRUST OF THE IVREA CRUSTAL SECTION (SOUTHERN ALPS)

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The South Alpine domain of northwest Italy exposes a nearly complete section of the continental crust (e.g., Pistone et al. 2017). The present study deals with a lens consisting of mantle peridotites and amphibolites (1.5 km long and up to 400 m thick) enclosed at mid crustal levels (Alpe Morello locality), along the tectonic line separating the Ivrea-Verbano Zone from the Strona-Ceneri Zone. The Alpe Morello mantle peridotites show a widespread recrystallization under tremolite-chlorite facies metamorphic conditions, with a main foliation that is concordant with the hornblende + plagioclase foliation of adjacent amphibolites. The peridotite-amphibolite association is enclosed within sillimanite-bearing, amphibolite facies metasediments. The amphibolite facies metamorphism is believed to develop in response to the post-collisional Variscan evolution, before a major event of magmatic underplating dated at ca. 290 Ma. The entire Alpe Morello rock sequence is locally crosscut by peraluminous granitoid dykes that are most likely genetically related to nearby plutons dated at ca. 280 Ma.

The mantle peridotites frequently includes pyroxenite and gabbro layers that locally retain relics of mineral assemblages predating the amphibolite facies regional metamorphism. Primary textures and mineral chemical compositions document that the layers formed by intrusion of MORB-type melts giving rise to clinopyroxenite to gabbronorite protoliths. Transition of these rocks to eclogite facies conditions is shown by formation of Mg-rich garnet in Al-rich pyroxenites, and of Mg-rich garnet + Na-Ca-clinopyroxene (+ accessory rutile and kyanite) in gabbronorites. The eclogite facies metamorphism was followed by development of granulite facies assemblages, characterized by accessory spinel and sapphyrine in the pyroxenites and the gabbronorites, respectively. The amphibolites adjacent to the mantle peridotites show: (i) evidence for being formed by gabbroic protoliths, and (ii) relics of an eclogite facies mineral assemblage similar to that of eclogitized gabbronorite layers within the mantle peridotites. The geodynamic mechanisms leading to incorporation of a mantle sequence preserving eclogite and granulite facies relics in the middle continental crust will be examined.

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CAMPING IN THE IVREA ZONE, ITALY

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New high-precision geochemical and isotopic data show that magmas related to the Central Atlantic Magmatic Province (CAMP) were emplaced at the base of the continental crust in the Ivrea Zone of NW Italy. The new results significantly extend the presently known footprint of one of the largest examples of Large Igneous Province (LIP) on the planet. The La Balma Monte Capio (LBMC) intrusion is mafic-ultramafic in composition, ranging from dunitic at the base to plagioclase-bearing pyroxenitic at the top. Whole-rock MgO contents range from 38-43 wt% in the basal dunites to 17-24 wt% in the overlying, more differentiated plagioclase-pyroxenites. REE patterns are flat to LREE-enriched; whereas the Sr-Nd-Hf-Pb isotope signature of the LBMC intrusion is within the isotopic range of other mafic and ultramafic intrusions in the area (e.g. Fiorentini et al., 2018), its platinum group element signature is notably depleted. In terms of multiple sulfur isotope systematics, the Ni-Cu-PGE mineralization associated with the LBMC intrusion ranges between mantle-like and much heavier ($\delta^{34}S$= 6‰) values, thus indicating the local role of crustal contamination in mineralizing processes. Zircons were extracted from two samples at different levels within the LBMC intrusion, and were dated using the CA-IDTIMS U-Pb method. The two weighted-mean $^{206}Pb/^{238}U$ ages at 200.5 ± 0.3 Ma and 200.2 ± 0.5 Ma indicate a short-lived magmatic system that fractionated in place. The timing of emplacement is very different from that of all other mafic-ultramafic intrusions in the Ivrea Zone, and is consistent with magmatism associated with CAMP. The proposed temporal and genetic link between early Jurassic (200 Ma) mafic magmatism in the Ivrea Zone and the CAMP is supported by the position of the Ivrea Zone near a major lithospheric suture, the Insubric Line, which separates the European and Adria plates. Emplacement of mantle-derived magmas is commonly localised along lithospheric boundaries, as is the occurrence of magmatic Ni-Cu-PGE mineralization (Begg et al., 2010), preferentially in areas where previous sulfur and metal enrichment of the lower continental crust may enhance localised sulfide saturation in ascending mantle-derived magmas. Trans-lithospheric structures may be critical for magma ascent at the margins of LIP systems where melt production and migration may be weaker than at their cores.

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MELT-DUNITE INTERACTIONS AT 0.5 AND 0.7 GPA: AN EXPERIMENTAL STUDY ON THE ORIGN OF OLIVINE-RICH TROCTOLITES

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Text of Olivine-rich troctolites and dunites are diffuse at crust-mantle transition of the oceanic lithosphere. Disequilibrium textures coupled to mineral compositions indicate that melt-rock reactions play an important role in their origin. Olivine-rich troctolites are likely related to extensive melt impregnation of precursor mantle dunite.

In order to provide experimental constraints, we performed reactive dissolution and crystallization experiments by juxtaposing three variably evolved MORB-type glasses with pre-impregnated San Carlos olivine at 1300°C and then cooling to 1150°C at constant pressure (0.5 and 0.7 GPa). Additionally, an isothermal experiment (0.7 GPa, 1250°C) provides a snapshot of olivine-melt reaction after the high-temperature step.

Runs result in glass-bearing gabbro overlain by olivine-rich troctolite (at 0.5 GPa) or dunite (at 0.7 GPa) showing disequilibrium textures comparable with natural occurrences typically related to melt-rock reaction, e.g. embayed and resorbed subhedral olivine with lobate contacts against plagioclase and clinopyroxene, often occurring as large poikiloblasts including rounded olivines. Modal abundance of interstitial phases and mineral chemistry are strongly controlled by the extent of reacting melt infiltrated into the dunite matrix, i.e. the melt/olivine ratio. We found that higher pressure further limits olivine dissolution and results in a lower high-T porosity, decreasing the final abundance of interstitial phases.

Olivine composition is mostly buffered by the starting San Carlos olivine, resulting in high X_{Mg} (0.88-0.90). NiO content decreases at increasing melt/olivine ratio, matching the composition of olivine in natural samples. Remarkably, at very low melt/olivine ratio, NiO can exceed the starting San Carlos value as a result of the increase of Ni olivine-melt partition coefficient during cooling after olivine assimilation in reacted melt. This might potentially produce high-Ni magmatic olivine.

Melt composition affects the chemistry of interstitial minerals that show large compositional variability (anorthite in plagioclase, TiO_2 in clinopyroxene) as a result of local equilibrium driven by trapped melt effect. Remarkably, mineral co-variation trends (e.g. plagioclase anorthite vs. olivine X_{Mg}) match those of some natural olivine-rich troctolites settings.

Experimental results corroborate and constrain the lead role of melt-rock reactions in the origin of olivine-rich rocks at mantle crust transition in the oceanic lithosphere.

DYNAMICS OF HIGH-PRESSURE DESERPENTINIZATION IN SUBDUCTING SLABS: INSIGHTS FROM THE ALMIREZ ULTRAMAFIC MASSIF

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Prograde metamorphic devolatilization reactions are the principal source of fluids at intermediate depth of subducting slabs, and they essentially influence both the recycling of water in the Earth and the dynamics of subduction zones. The discontinuous dehydration of antigorite is one of the most important reactions, because it liberates the largest amounts of slab fluids. Although it is well known that far field stresses play a crucial role on fluid flow channeling, their potential impact on the kinetics of serpentinite dehydration and subsequent fluid escape is still poorly understood. Despite their fundamental role in subduction dynamics, the timescales and nature of deserpentinization fluid release are also poorly constrained.

Here we present microstructural data to investigate the relationship between far field stresses and deserpentinization reactions from an exhumed subduction terrane (Almirez Massif, S. Spain), and we show that fluid release during dehydration of serpentinite is episodic and driven by compaction. The Almirez massif preserves the high-pressure breakdown of antigorite (Atg-) serpentinite to prograde chlorite (Chl-) harzburgite (Padrón-Navarta et al., 2010-2012). The discontinuous nature of fluid release is recorded by the alternation of lenses of Chl-harzburgite with granofels and spinifex textures, which indicate crystallization under different overstepping of the Atg-out reaction. Mapping shows that lens thicknesses are consistent with the compaction length of serpentinite dehydration. The combination of μ-CT and EBSD data (Kahl et al., 2017) across a c. 15 m wide Chl-harzburgite lens reveals that the SPO and CPO of olivines are controlled by topotactic reaction with Atg-serpentinite in the granofels Chl-harzburgite. In the spinifex textures, olivines form elongated crystals that are tabular on (100) faces and elongated along [001] axis, and the tabular interfaces are oriented perpendicular to the maximum compressive stress axis inferred from field observation. This indicates oriented growth during episodes of enhanced reaction rates. We propose that at periods of high fluid flux due to hydrofracturing in a dehydrating slab, the development of fluid network channels strongly depends on the principal stress field. These results also demonstrate that deserpentinization fluid-release in a subducting slab is non-steady, likely accommodated by pulses of fluid-filled porosity waves.

Funded by the EU-FP7 Marie Curie Initial Training Network "ZIP" under GA PITN-GA-2013-604713, and NSF-PIRE Exterra under MINECO PCIN-2015-053.

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THE CRUST-MANTLE TRANSITION OF THE KHANTAISHIR OPHIOLITE (WESTERN MONGOLIA)

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The Khantaishir ophiolite, located in western Mongolia, shows a nearly complete ophiolitic pseudo-stratigraphy exposed over ~260 km^2, with a well-preserved crust-mantle transition (CMT). The ultramafic section is composed of variable serpentinized harzburgites, pyroxenites and dunites, while the lower plutonic crust is represented by hornblende-gabbros, tonalites and minor gabbronorites, which are intruded by pyroxenites and doleritic to andesitic dykes. The upper volcanic crust is formed by boninitic to andesitic lavas, that build a dyke and sill complex capped by pillow lavas. The harzburgites of the CMT are characterized by a progressive increase in the modal abundance of pyroxenes, that finally results in a 50-200 m thick uniform pyroxenitic layer at the contact with the overlying mafic section. This pyroxenitic layer, replacing the upper harzburgitic mantle, mainly consists of coarse-grained to pegmatitic olivine-websterites to websterites, with minor orthopyroxenites and rare clinopyroxenites. Most of the ultramafic rocks and gabbronorites show a depletion in high field strength elements (HFSE) and positive anomalies for Sr and Pb, whereas gabbros and tonalites are enriched in large ion lithophile elements (LILE) and have slightly enriched rare earth element (REE) patterns. Isotopes for the rocks of the CMT indicate that they have similar initial Nd compositions ($\varepsilon(\mathrm{Nd})_i$ = 4.0-6.9) suggesting a common mantle source for the melt. Moreover, Sm-Nd isochron calculations and geothermometry suggest that the CMT formed ~540 Ma ago at an intrusive temperature of 1100-1200 °C. Calculated liquids in equilibrium with cpx of the different rocks forming the CMT have the typical features of arc melts, such as positive anomalies for Pb and Sr, and negative anomalies for Ti and Zr-Hf. Additionally, these melts have trace element patterns that overlap the field of the boninitic to andesitic lavas from the upper volcanic section, indicating that the lithologies of the CMT and the overlying lavas are co-genetic and related by fractional crystallization processes. It is therefore concluded that the Khantaishir ophiolite represents a fragment of an oceanic island arc formed above a supra-subduction zone.

MELT-ROCK INTERACTIONS AT MANTLE CONDITIONS: INTRUSION OF GABBROIC DYKES IN THE SUB-CONTINENTAL FINERO MANTLE MASSIF

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The Finero Phlogopite-Peridotite (FPP) is a mantle massif recrystallized through several events of melt migrations. These events have enriched the FPP in crustal components (LILE and LREE) and hydrous phases (amphibole and phlogopite) and they have been suggested to be related to a subduction/post orogenic geodynamic setting. One of the latest metasomatic events is represented by the intrusion of sapphirine-bearing gabbroic dyke swarms. Dykes are formed by a Leucocratic Zone at the nucleus and a melanocratic zone characterized by a cumulus zone (the Early Amph Zone) bounded by two distinct reaction zones (the Opx Zone at the contact with the host and the Late Amph Zone at the contact with the Leucocratic Zone). This structure has been interpreted as a two-steps intrusion process, triggering the interaction of migrating melts with the host peridotite and the first cumulates. In the first step, the melt reacts with the FPP rocks forming the Opx Zone and evolves by fractional crystallization of amphibole cumulates. In the second step, an evolved melt reacts with the first cumulates producing metasomatic sapphirine and segregating plagioclase-rich bands containing abundant apatites at the nucleus of the dikes. New O, Sr and Nd isotopes on minerals suggest a more complex evolution.

The δ18O increases from 5.81‰ in orthopyroxenes at the dykes' border to ~6.90‰ in cumulitic amphiboles and 8.60‰ in plagioclases. The ^{87}Sr/^{86}Sr values for plagioclase and coexisting apatite show isotopic disequilibrium between the two phases. Similarly, Nd isotopic values suggest disequilibrium between plagioclase and at least one amphibole generation. These isotopic variations could be explained with a progressive contamination of the parent melt of the gabbroic dykes during its fractionation through an AFC-like process between mantle-derived melt(s) and a crustal-enriched host (the FPP).

The occurrence of abundant apatite and carbonate inclusions, together with the alkaline geochemical affinity suggest possible relationships between the gabbroic dykes and other alkaline/apatite-rich metasomatic events in the Finero Complex. This evidence correlates the gabbroic dykes' intrusions in the FPP with Triassic alkaline dykes within the Finero Mafic Complex, and the general Triassic alkaline magmatic activity recorded in the Ivrea-Verbano Zone.

Acknowledgements: funds provided by PRIN 2015 in the frame of project 20158A9CBM_005 and the Programma Giovani Ricercatori Rita Levi Montalcini to A.C.

THE CLASSIFICATION OF PHLOGOPITE-BEARING ULTRAMAFIC ROCKS: A NEW PROPOSAL

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In recent years, the many new occurrences reported in the literature of ultramafic rocks with phlogopite as a major constituent and not falling into the category of Kimberlites, Lamproites and Lamprophyres, have highlighted the need of a classification that includes this abundant mineral phase. Currently, a broadly accepted classification with phlogopite does not exist and the only term used by scientists is 'bearing phlogopite' in association with the current classification of ultramafics, thus not considering the % of phlogopite volume, which can vary from 5 % by Vol. up to 90 %. Moreover, some of the nomenclature used to describe this type of rocks is rather obsolete. For example, the term "Abessedite" indicates a variety of peridotite composed of olivine, hornblende and phlogopite, the name "Pikeite" denotes a phlogopite peridotite, or "Scyelite" that describes an olivine-hornblendite with phlogopite For this reason, we propose a new classification that integrates phlogopite into the current classification of ultramafic rocks, without modifying the already accepted terminology or the classificative criteria (i.e. the mineral modal abundances). Phlogopite is added as an end-member in the ultramafic rocks classification diagrams, changing their shapes from triangular to tetrahedral. The new tetrahedral classification has also been implemented, in relation to the hornblende-bearing ultramnafic rocks, to include both ortho- and clinopyroxene at the vertices of the diagram, combining the Ol-Opx-Cpx and Ol-Px-Hbl diagrams. This allows a more specific and accurate classification of samples. An excel spreadsheet containing the new diagrams and a macro that automatically classifies the rocks is presented.

CONTAMINATION PROCESSES DURING THE INTRUSION OF THE TONIAN GOIÁS STRATIFORM COMPLEX: A MULTI-ISOTOPE INVESTIGATION

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The Tonian Goiás Stratiform Complex (TGSC, Goiás, central Brazil), is one of the largest mafic-ultramafic layered complexes in the world, emplaced during the geotectonic events that led to the Gondwana accretion. We present trace elements and in-situ U/Pb - Lu-Hf analyses of zircons and $^{87}Sr/^{86}Sr$ ratios of plagioclases from anorthosites and gabbros of the TGSC to investigate the processes that have controlled the intrusion of this huge volume of mantle-derived melts in the lower crust. Although formed by three isolated bodies (Cana Brava, Niquelândia and Barro Alto), and characterized by a Lower and an Upper Sequence (LS and US), our new U/Pb zircon data confirm recent geochemical, geochronological, and structural evidences that the TGSC has originated from a single intrusive body, long ca. 350 km and thick ca. 20 km, in the Neoproterozoic. New isotopic ratios reveal a complex contamination history for the TGSC, with different geochemical signatures in the two sequences. The low Hf and high Sr isotope ratios of the Lower Sequence suggest the presence of a crustal component and are consistent with contamination from meta-pelitic and calc-silicate rocks found as xenoliths within the Sequence. The more radiogenic Hf isotope ratios and low Sr isotope composition of the Upper Sequence suggest a contamination from mantle-derived metabasalts in agreement with the occurrences of amphibolite xenoliths in the US stratigraphy. The differential contamination of the two sequences is explained by the intrusion of the TGSC parental melt in a stratified crust dominated by metasedimentary rocks in its deeper part and metavolcanics at shallower levels. Moreover, the differential thermal gradient in the two crystallizing sequences might have contributed to the preservation and recrystallization of inherited zircon grains in the US and total dissolution or magmatic overgrowth of the LS zircons via melt/rock reactions processes.

Acknowledgements: this work was supported by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) in the frame of the project 2013/19519-6 to TG.

Analytical facilities and their development have been funded by the MIUR PRIN 2015 Prot. 20158A9CBM_005 to MM and Programma Giovani Ricercatori "Rita Levi Montalcini" to AC.

OLIVINE, KIMBERLITES AND THE MODIFICATION OF CARBONATED MELTS IN THE DEEP EARTH

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Olivine in kimberlite rocks is typically zoned regardless of shape and size. The rims contain primary inclusions of groundmass phases (e.g., chromite, ilmenite), and exhibit homogeneous Mg# composition coupled with decreasing Ni and increasing Ca and Mn concentrations. These features are consistent with a magmatic origin for the rims. Conversely, the olivine cores may host inclusions of mantle phases (e.g., clinopyroxene, garnet) unstable in kimberlite magmas. The cores show widely variable compositions extending from those of olivine in mantle peridotites (i.e. Mg# ~ 90-94) to compositions richer in Fe, and derive from disaggregation of mantle wall rocks. The magmatic rims of olivine can threfore be employed as proxies of the composition of kimberlite melts, whereas the xenocrystic cores can provide constraints on the composition of the lithospheric mantle traversed by kimberlite magmas. To understand the role, if any, of assimilation of lithospheric mantle material in the origin of kimberlites and other carbonate-rich magmas, we have examined major-element compositions of olivine in kimberlites and orangeites from South Africa, Botswana, Lesotho, Canada, Brazil, Russia and Greenland. Different kimberlite pipes from individual clusters (e.g., Kimberley in South Africa, Ekati in Canada) contain olivine with very similar compositional features (e.g., restricted range of rim Mg#). However, large compositional variations are evident for olivine grains from kimberlite clusters on the same craton and worldwide. The most remarkable finding of this study is the statistically significant ($R^2 = 0.8$) linear correlation between the Mg# of olivine cores and rims in kimberlites worldwide, which extends to South African orangeites and rocks from Brazil and Greenland with transitional features between kimberlites and ultramafic lamprophyres. The correlation between Mg# of (xenocrystic) cores and magmatic rims suggests that the composition of wall rocks along the magma conduit exerts a fundamental control on the composition of the olivine rims and, therefore, kimberlite magmas. This process also applies to other mantle-derived carbonate-rich magmas (e.g., orangeites) and might potentially affect the composition of any carbonated melt in the deep Earth.

DOI:10.19276/plinius.2018.03015

IN-SITU IRON OXIDATION STATE IN THE UPPER MANTLE MINERALS USING ELECTRON MICROPROBE

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The oxidation state of the Earth's mantle is a key parameter that affects the volatile contents of basaltic magmas, their degassing behaviour and the formation of some mineral deposits. The mantle's oxidation state is strongly influenced by the distribution of redox-sensitive volatile element species (e.g., CO_2, CH_4), but also by the abundance and distribution of ferric iron (Fe^{3+}). The key parameter in redox estimates for mantle rocks is the $Fe^{3+}/\Sigma Fe$ ratio in the upper mantle mineral assemblage represented by olivine, pyroxenes and garnet or spinel (Frost and McCammon 2008). The most reliable $Fe^{3+}/\Sigma Fe$ data for mantle minerals have been obtained for over two decades by Mössbauer spectroscopy. However, Mössbauer measurements of $Fe^{3+}/\Sigma Fe$ were done for relatively large aliquots of mineral separates only ((Nimis et al. 2015)). This approach excludes the possibility to explore the zoning of $Fe^{3+}/\Sigma Fe$ in individual grains, heterogeneity between different grains and mineral intergrowths to investigate multi-stage histories and secondary alteration. In this study a rarely applied *in situ* approach used to study iron oxidation state by EPMA in rock thin sections at high spatial resolution. The "flank"- method is based on the sensitivity of intensities and shifts of iron L-lines to its oxidation state in X-ray wavelength-dispersive spectra and allows examination of $Fe^{3+}/\Sigma Fe$ within individual mineral grains. The "flank" approach were moderately used over last decades to study $Fe^{3+}/\Sigma Fe$ in mantle garnets after procedure developed by (Höfer and Brey 2007) and showed a good agreement with Mossbauer data. Another important redox and $Fe^{3+}/\Sigma Fe$ proxy – mantle spinel, were studied within this project. Calibration standards of spinel of variable compositions were synthesized at SPSU and characterized for their $Fe^{3+}/\Sigma Fe$ at SPSU using Mössbauer spectroscopy. A "flank" calibration procedure was designed for the JEOL JXA-8200 EPMA at Free University of Berlin. The results for garnet-spinel peridotites from Vitim plateau and Udachnaya kimberlite pipe (Siberia, Russia), as well as results for peridotites representing ophiolites complexes showing significant zoning for mineral individual grains in terms of $Fe^{3+}/\Sigma Fe$ and calculated oxygen fugacity.

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SOURCES AND BEHAVIOUR OF CARBON-RICH FLUIDS IN THE LITHOSPHERIC MANTLE: INSIGHTS FROM OFF-CRATON

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Oxygen fugacity (fO_2) is a key parameter of Earth's mantle, because it controls the speciation of fluids migrating at depth ; a major question is whether the sublithospheric mantle is metal-saturated, keeping fO_2 near the Iron-Wustite (IW) buffer reaction. Cretaceous basaltic pyroclastic rocks on Mt. Carmel, Israel erupted in an intraplate environment with a thin, hot lithosphere. They contain abundant aggregates of hopper-shaped crystals of Ti-rich corundum, which have trapped melts with phenocryst assemblages (Ti_2O_3, SiC, TiC, silicides, native V) requiring extremely low fO_2. These assemblages are interpreted to reflect interaction between basaltic melts and mantle-derived fluids dominated by CH_4 + H_2. Similar highly reduced assemblages are associated with volcanism in a range of tectonic situations including subduction zones, major continental collisions, intraplate settings, craton margins and the cratons sampled by kimberlites. This distribution, and the worldwide similarity of $d^{13}C$ in mantle-derived SiC and associated diamonds, suggest a widespread process involving similar sources and independent of tectonic setting. We suggest that the common factor is the ascent of abiotic (CH_4+H_2) fluids from the sublithospheric mantle; this would imply that much of the sublithospheric mantle is metal-saturated, consistent with observations of metallic inclusions in sublithospheric diamonds (e.g. Smith et al., 2016, 2017). Such fluids, perhaps carried in rapidly ascending deep-seated magmas, could penetrate high up into a depleted cratonic root, establishing the observed trend of decreasing fO_2 with depth (e.g. Yaxley et al., 2012, 2017). However, repeated metasomatism (associated with the intrusion of silicate melts) will raise the FeO content near the base of the craton over time, developing a carapace of oxidized material that would prevent the rise of CH_4-rich fluids into higher levels of the SCLM. Oxidation of these fluids would release CO_2 and H_2O to drive metasomatism and low-degree melting both in the carapace and higher in the SCLM. This model can explain the genesis of cratonic diamonds from both reduced and oxidized fluids, the existence of SiC as inclusions in diamonds, and the abundance of SiC in at least some kimberlites. It should encourage further study of the fine fractions of heavy-mineral concentrates from all types of explosive volcanism.

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MOISSANITES OF THE POPIGAI IMPACT CRATER

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Moissanite crystals, 250-400 µm, have been found in tagamite of the Popigai impact crater and studied by X-ray diffraction (XRD). All fifty analysed moissanite samples are of hexagonal SiC modifications. Neither sample is of a purely cubic habit, though cubic modifications may be part of SiC-6H and SiC-15R hexagonal crystals which have coinciding diffraction lines.

The SiC-6H polytype is observed in most of the moissanite samples varying in color from pale to dark blue. Among 40 grains, three black (dark blue in transmitted light) crystals represent the SiC-4H polytype and three black and one pale yellow ones belong to the SiC-15R polytype. The SiC-6H moissanite is intergrown with SiC-15R (6H/15R) in two cases and with and SiC-4H (6H/4H). In one sample, the SiC-6H modification coexists with SiC-8H (6H/8H). The SiC-8H modification is known to form at temperatures above 2750 °C, and only together with 6H. Our results, along with known temperature limits for the SiC-15R origin, place the formation temperature of the Popigai moissanites within the 2200 to 2750 °C range.

The work was supported by grants 16-05-00873 and 17-17-01154a of the Russian Foundation for Basic Researchers and was carried out as a part of the Project No 0330-2016-0006.

EXPERIMENTS ON MELT FORMATION AND METASOMATISM FROM A MIXED LHERZOLITE + KAERSUTITE-RICH MANTLE SOURCE

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It is well known that the high Na/K alkaline basalts from intraplate continental and oceanic settings demonstrate substantial geochemical similarities suggesting comparable petrogenesis (Pilet, 2015). In the early seventies it was proposed that these lavas are produced by small degree of partial melting of a peridotitic mantle source (Hart, 1971) but more recent data show that the trace element and isotopic signatures of high Na/K alkaline basalts from intraplate continental and oceanic settings may be derived from a more enriched source than the fertile lherzolite mantle. Several models are proposed for this enrichment, including recycling of oceanic lithosphere into the Earth's convecting mantle with subsequent transformation into pyroxenitic/eclogitic lithologies, "digestion" of enriched lithospheric mantle via subduction, delamination, or interaction with plumes as well as metasomatic mantle enrichment which may lead to the formation of volatile-rich veins in oceanic and continental mantle lithosphere (Pilet, 2015). To experimentally simulate mantle melting of a metasomatised peridotite, we performed high-pressure high-temperature experiments between 2 and 4 GPa. Our starting material consists of layers of lherzolite (KLB-1) and natural kaersutite-rich metasome (Grützner *et al.,* 2013). The experiments were designed to systematically investigate the effects of the P-T on major and trace element compositions of the partial melts. In the conference, we will present first results together with some implications for mantle metasomatism.

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EXPERIMENTAL EVIDENCE FOR RUTHENIUM ISOTOPE FRACTIONATION BETWEEN LIQUID METAL AND LIQUID SILICATE

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The abundances of highly siderophile elements (HSE, e.g. Ru) in Earth's mantle are generally assumed to reflect late accretion of on average broadly chondritic material to Earth's mantle after the cessation of core formation. Yet, for some HSE (Ru, Pd) it has also been suggested that their mantle abundances reflect metal-silicate equilibration during core formation, and not late accretion (Righter *et al.*, 2008; Brenan & McDonough, 2009; Mann *et al.*, 2012, Rubie *et al.*, 2016). Distinguishing between these two possibilities and thus constraining the roles of late accretion and core formation in establishing the mantle abundances of the HSE is important for understanding the terminal stages of terrestrial core formation and for assessing the origin and nature of the material added to the Earth during late accretion. These issues can be addressed using mass-dependent isotope fractionations of some HSE. With regard to their isotopic composition, HSEs in the mantle can principally inherit two distinct signatures. HSEs remaining in the mantle after core formation might exhibit mass-dependent isotope fractionations resulting from metal-silicate fractionation. By contrast, HSEs delivered during late accretion should show no isotope fractionation due to core formation. To quantify the magnitude and direction of any mass-dependent Ru isotope fractionation during core formation, we performed metal-silicate partitioning experiments in a piston cylinder apparatus at Münster University with large volume MgO single crystal capsules at 1 GPa and temperatures between 1300 °C and 1600 °C. From the experimental results we determined both Ru partitioning and the isotope fractionation of stable Ru isotopes as a function of temperature, composition and fO_2. After characterization of the experiments, metal and silicate were mechanically separated and further processed for the determination of Ru concentrations and isotopic compositions using double spike MC-ICP-MS (Hopp *et al.*, 2016). So far, one set of experiments has been completely analyzed. The Ru isotopic compositions of the metal phases are uniform and are indistinguishable from the isotopic composition of the starting material. By contrast, silicates separated from four individual display lighter Ru isotopic compositions relative to the metal, suggesting that there is resolvable mass-dependent Ru isotope fractionation between liquid metal and liquid silicate. Surprisingly, the metal-silicate partition coefficients for Ru, determined by isotope dilution on bulk silicates and metal samples from the experiments, are much lower compared to previously reported values (Laurenz *et al.*, 2013). At the conference we will present the most recent results and first implications of this study.

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ITALIAN KAMAFUGITES REVISITED: FINGERPRINTING DIFFERENT METASOMATIZED MANTLE COMPONENTS USING OLIVINE GEOCHEMISTRY

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Kamafugites are primitive, ultrapotassic rocks, characterized by extreme silica undersaturation, low Al_2O_3 and strongly elevated CaO contents. The origin of the Italian kamafugites is still a matter of debate, not least due to the "crustal signature" displayed by trace elements and isotopic ratios (Conticelli & Peccerillo, 1992). The most recent approach (Ammannati *et al.*, 2016) suggests the recycling of carbonate-rich sediments into the mantle wedge, leading to the formation of phlogopite-rich wehrlites being a viable source for the Italian leucitites, which are genetically closely related to the kamafugites.

In this study, we combine *in-situ* EMPA and LA-ICP-MS analyses with *in-situ* analyses of oxygen isotopes (SIMS) on olivine from the Pleistocene San Venanzo lavas (Italy), aiming to put more constraints on the origin of Italian kamafugites. We recognize 3 genetically different olivine groups: i) group 1 phenocrystic grains with Mg# of 89.9-92.8, very low Ni (<1000 µg/g), high Ca (>3600 µg/g) and Mn of 990-1900 µg/g. Their $\delta^{18}O_{vsmow}$ is strongly elevated (10.3-10.9 ‰); ii) group 2 xenocrystic grains are dominant; they demonstrate reverse zoning with very forsteritic cores having Mg# of 91.5-93.5, high Ni (up to 4500 µg/g), low Mn (~600-900 µg/g) and Ca from ~1000-1500 µg/g, compositionally resembling the olivine typically found in Mediterranean lamproites (Prelević & Foley, 2007). Their $\delta^{18}O_{vsmow}$ is, similar to group 1 olivines, strongly elevated (9.2-10.6 ‰); iii) group 3 includes rare olivine grains of extreme Mg# (98.2-99.5) and $\delta^{18}O_{vsmow}$ (~27 ‰) and negligible amounts of minor and trace elements.

Our working hypothesis is that the mantle source of Italian kamafugites must be compositionally heterogeneous on very small scales. The dominant source of the melts that crystallized group 1 olivine resembles phlogopite-wehrlite metasomes generated after recycling of carbonate-bearing sediments. The melts that crystallized group 2 olivine are derived from a phlogopite-pyroxene-rich metasome, generated by recycling of less Ca rich, pelitic sediments. The high $\delta^{18}O_{vsmow}$ of group 3 olivine possibly hints to a skarn-related origin and thus to shallow level processes. In summary, we propose that the interaction of 3 different reservoirs led to the formation of San Venanzo kamafugite, what offers a new perspective on the petrogenesis of the Italian kamafugites.

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ANDEAN-TYPE LATE NEOPROTEROZOIC SUBALKALINE MAGMATISM IN SOUTHERN TURKEY: EVIDENCE FOR AN ACTIVE CONTINENTAL MARGIN IN THE PERI-GONDWANAN REALM

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The Gondwanan Late Neoproterozoic successions in Turkey mainly crop out in the Tauride-Anatolide Platform (TAP) and the South Anatolian Autoctone Belt (SAAB) of the northern Arabian Plate. Neoproterozoic meta-granitic (~542 Ma-Gürsu and Göncüoğlu, 2008) and meta-pelitic basement rocks are unconformably overlain by trace fossil bearing Early Cambrian volcaniclastics (e.g. Erdoğan et al., 2004; Demircan et al., 2018) and Middle Cambrian trilobite-rich meta-carbonates (Dean and Özgül, 1994) in the Sandıklı (TAP), Menderes Massif (TAP) and Derik (SAAB) areas. Late Neoproterozoic basement rocks in the Sandıklı area comprise meta-siliciclastics associated with meta-felsic volcanic rocks (543±7 Ma - Gürsu & Göncüoğlu, 2006) and are crosscut by meta-quartz-porphyry dykes (541.3±10.9 Ma - Gürsu & Göncüoğlu, 2006). Late Neoproterozoic basement rocks in Menderes Massif start with meta-tonalities/meta-granodiorites (580 - 570 Ma; Koralay, 2015) and meta-granitic rocks (augen gneisses, biotite-rich granite mylonites and tourmaline-rich granite mylonites; ~542 Ma - Gürsu, 2015). Similar successions are also observed in the Derik (Mardin) area and include Late Neoproterozoic early-stage andesites (~582 Ma) and rhyolites (570 Ma) (Gürsu et al., 2016) alternating with pyroclastic rocks and rare siltstone/sandstone intercalations. They are cut by late-stage andesitic lavas (560 Ma - Gürsu et al., 2017) and mafic dykes. The uppermost part of the succession contains pyroclastic rocks (mostly tuffs) associated with agglomerates/volcanic breccias. Andean type arc-related igneous activity at 580-560 Ma was derived from a depleted mantle source ($Nd_{(T)}$: +0.15 to +4.20). This was followed by post-collisional granitic magmatism ($Nd_{(T)}$: -4.63 to -0.54) at 530-560 Ma emplaced during late- to post-collisional back-arc extension behind the Cadomian arc. This was concomitant with southward subduction of the Proto-Tethys Ocean along the northern margin of Gondwana. Lithospheric thinning and back-arc development in peri-Gondwanan continental crust resulted in development of N-MORB type gabbroic stocks, mafic lavas and dykes in the TAP between 560 and 530 Ma just behind the Cadomian arc. Similar tectonic scenarios have been suggested for other peri-Gondwanan terranes in Europe to the Middle East to eastern Asia (details in Gürsu, 2015).

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DOI:10.19276/plinius.2018.03015 PLINIUS n. 44, 2018

CONTINENTAL RIFT RELATED EARLY CAMBRIAN THOLEIITIC MAGMATISM IN THE TAURIDE-ANATOLIDE PLATFORM, WESTERN TURKEY

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Gondwanan-origin rift-related Early Cambrian tholeiitic magmatism occurred in the Taurides and Menderes Massif (MM) of the Tauride Anatolide Platform (TAP). The Early Cambrian succession in the Taurides starts with basal meta-congolomerates, and meta-siliciclastics associated with meta-pyroclastics, meta-basaltic lavas and meta-mafic dykes (Gürsu and Göncüoğlu, 2005). It conformably continues with Early Cambrian meta-silisiclastics and Middle Cambrian trilobite bearing meta-carbonate successions (Dean and Özgül, 1994). Similar successions in the MM (Alaşehir) are unconformably overlain by Late Neoproterozoic basement rocks and are mainly composed of meta-siliciclastic rocks and frequently crosscut by biotite-rich gabbros. These meta-mafic rocks in the Taurides have slightly lower Zr/Nb (<7.3) and La/Nb (<0.43), but higher Zr/Y (<2.30), Th/Ta (<2.66), Th/Yb (<0.25) and Ta/Yb (<0.05) ratios than N-MORB. Multi-elemental diagrams of the meta-mafic rocks in the Taurides show pronounced negative Nb and Ti anomalies with enrichment in LILE rather than HFSE and positive $(Eu/Eu^*)_N$ implying a subduction-related origin. The low (La/Nb)/Y (<0.045), V/Ti (<0.065) ratios and lower Zr values (<109.40 ppm) ratios of the meta-mafic rocks have similarities with typical back-arc basin basalts (Floyd et al., 1991; Woodhead et al., 1993). Th, Nb, Zr, Y and Ti contents of the meta-gabbros in Alasehir area (MM) are range from 0.2 - 1.2 ppm, 0.6 - 4.9 ppm, 14.8 - 59.9 ppm, 8.4 - 15.0 and 2520 - 6180 ppm, respectively, and have low $(La/Yb)_N$, $(La/Sm)_N$, $(Gd/Yb)_N$ and $(Eu/Eu)_N$ ratios. The meta-gabbros are highly depleted in LREE and display flat MREE and HREE patterns. The high Ti/Zr (>98.4) and low Zr/Yb (<41.3) ratios of the meta-gabbros indicate that they may have been generated from a depleted-mantle source in a back-arc tectonic environment. Andean-type magmatism of the Late Neoproterozoic basement rocks in the TAP was followed by initial stages of extension and resulted in lithospheric thinning. A mature stage of rifting of the continental crustal part may have resulted in the formation of the biotite-rich meta-gabbroic dikes at ~ 545 to 530 Ma. The geodynamic model proposed here works well in other peri-Gondwanan terranes in the southern and middle margin of Europe and the southern margin of Asia during the Late Neoproterozoic and Early Cambrian time interval representing the northern part of Gondwana.

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DOI:10.19276/plinius.2018.03015

VARIATIONS IN THE H_2O CONTENT AND H_2O/Ce RATIO OF MANTLE PYROXENITES: IMPLICATIONS FOR ENRICHED COMPONENTS IN THE MANTLE

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Mantle pyroxenite xenoliths were collected from Hannuoba, East China, and investigated for their H_2O content and trace element contents, with particular regard to the H_2O/Ce ratio. The pyroxenites were divided into three groups: Cr-pyroxenites, Al-pyroxenites, and garnet pyroxenites. The H_2O contents and H_2O/Ce ratios of the pyroxenites in this study showed much wider ranges than those previously reported for pyroxenites. The Cr-pyroxenites had an H_2O content ranging from 23 to 339 ppm and an H_2O/Ce ratio between 32 and 212; the Al-pyroxenites had an H_2O content ranging from 42 to 106 ppm and an H_2O/Ce ratio between 1 and 22, and the garnet pyroxenites had an H_2O content ranging from 37 to 69 ppm and an H_2O/Ce ratio between 5 and 54. These systematic variations in the H_2O contents and H2O/Ce ratios for the Hannuoba pyroxenites are associated with their origins. Both the H_2O content and H_2O/Ce ratio of the Al-pyroxenites were low compared to those of Hawaiian pyroxenite, enriched mantle, and depleted MORB mantle sources. The high H_2O content and H_2O/Ce ratio of the melt equilibrated with the Cr-pyroxenites indicates that a water-rich component was involved in its formation. Their large variations in the H_2O contents and H_2O/Ce ratios may indicate that pyroxenites are essential ingredients as enriched components in the sources of continent basalts.

MICROSTRUCTURE OF LAYERED ULTRA MAFIC CUMULATES: CASE STUDY OF THE BEAR CREEK INTRUSION, TRINITY OPHIOLITE, CALIFORNIA, USA

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In the Trinity Ophiolite, California, USA, mafic-ultramafic plutons with an arc petro-geochemical affinity intruded mantle peridotites that were accreted along a marginal oceanic spreading centre (Ceuleneer and Le Sueur, 2008). In this work, we report the microstructures of a consistent sequence of dunites and pyroxenite-rich layered cumulates (embedded in mantle harzburgite and lherzolite) from one of these plutons cropping out in the Bear Creek area. In the lowermost part of the Bear Creek intrusion, Electron Back-Scattered Diffraction (EBSD) data coupled with field observations suggest deformation by dislocation creep of the dunites in the presence of interstitial melt, consistent with the regional stretching direction (N130) of the surrounding mantle peridotite. This deformation event was then followed by an annealing episode. Upsection in the layered cumulates, EBSD analysis emphasizes a strong planar fabric and a weak lineation for all minerals that is observed in the field. Fabrics of clinopyroxene ([001] (010)), orthopyroxene ([001] (010) and [001](100)) and olivine ([001](010)) suggest that both viscous deformation (i.e. compaction) and deformation by dislocation creep were recorded. The latter overprints the magmatic fabric and is consistent with a high-temperature environment accompanied by the presence of interstitial melt. Our results show that pyroxenites that have evolved under crustal conditions, may carry different fabrics from those of their mantle counterparts (e.g., Henry et al, 2017). This potentially affects the interpretation of the seismic signal as the anisotropy of the seismic waves is a direct consequence of the mineral fabrics.

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IMPACT OF FLUID-INFILTRATION ON THE MORPHOLOGY OF PROGRADE OLIVINE DURING HIGH-PRESSURE ATG-SERPENTINITE DEHYDRATION

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Crystal morphologies are essential for deciphering the reaction history of igneous and metamorphic rocks because they often record the interplay between nucleation and growth rates controlled by the departure from equilibrium (i.e., the reaction affinity). We report a unique record of morphological transition in olivine from a chlorite harzburgite formed by high-pressure dehydration of antigorite serpentinite from the Almirez Massif (Betic Belt, Nevado-Filábride Complex, S. Spain). Correlative X-ray μ-CT and EBSD in a varied-textured Chl-harzburgite unveils the presence of composite olivine grains made up of large equant cores mantled by epitaxially grown coronas of tabular olivines with a spinifex-like morphology. Olivine in overgrown coronas is tabular on (100) with $c > b >> a$, which strongly differs from anisotropic olivines in igneous and metamorphic systems, where reported morphologies are tabular on (010) with either $a > c >> b$, or $a \sim c >> b$ (Donaldson, 1976; Shore and Fowler, 1999; Faure et al., 2003). Coronas of tabular olivine on equant grain substrate record a shift from isotropic to strongly anisotropic growth due to inhibited growth on the (100) and, to a lesser extent, (010) olivine interfaces. Inhibited growth along these interfaces is predicted in crystals that grow from highly polymerized fluids due to the dissociative and molecular adsorption of water monolayers on (100) and (010) olivine interfaces, respectively. This morphological transition likely records the open-system arrival of highly polymerized aqueous fluids during the late stages of Atg-serpentinite dehydration in a subduction setting. These results show that, besides reaction affinity, surfactants may play an important role in shaping the morphology of growing crystals during metamorphism.

We acknowledge funding by the EU-FP7 Marie Curie Initial Training Network "ZIP" under GA PITN-GA2013-604713, and NSF-PIRE “EXTERRA” under MINECO PCIN-2015-053.

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DEFORMATION AND MELT-ROCK REACTIONS IN THE SHALLOW SUBCONTINENTAL LITHOSPHERIC MANTLE BENEATH ORAN (TELL ATLAS, N-ALGERIA)

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The Betic-Rif-Tell arc-shaped mountain belt in the westernmost Mediterranean is formed during the Miocene collision between the Alborán domain and the south Iberian and Maghrebian passive margins. In this area, subcontinental lithospheric mantle (SCLM) is outcropped either as exhumed ultramafic massifs (Hidas et al., 2013) or as mantle xenoliths (e.g., Rampone et al., 2010; Hidas et al., 2016; Marchesi et al., 2017). Plio-Pleistocene alkali basalts in the southern limb of the mountain belt contain large amounts of Plag- to Spl-facies peridotite mantle xenoliths.

Here we report geochemical and microstructural data of metasomatized mantle xenoliths from the Oran area of the Tell Atlas (North Algeria). We focus on rock samples where refertilization (crystallization of Cpx + Opx at the expense of Ol) and wehrlitization (crystallization of Cpx ± Ol at the expense of Opx) are suggested by textural observations, resulting in transitional lithologies from Spl-facies, coarse-grained lherzolite and harzburgite protolith ($T_{Cpx\text{-}Opx}$: 980-1050°C) to fine-grained, Spl/Plag-facies Cpx-rich wehrlite. In the nearly unaffected coarse-grained protoliths, constituent phases reflect usual SCLM major and trace element geochemical compositions with Mg# in the range of 90-92 but Opx is often rimmed by Cpx. In these Opx-Cpx assemblages, the formation of Cpx after Opx is supported by the embayed contact and the identical crystallographic preferred orientation (CPO) of these two phases. In the wehrlitic textures, secondary Cpx ± Ol ± accessory phases form along veins and modify the geochemical composition of the minerals, shifting Mg# towards values in the range of 88-86. Wehrlitic lithologies also show an important enrichment in LREE in Cpx yet with MREE/HREE ratios comparable to those in protolith. This geochemical variation is coupled to the dispersion of Ol CPO in the wehrlitic samples, with respect to the relatively strong axial-[100] CPO type of the protolith.

The lithological, textural and geochemical variations in the studied xenoliths from N-Algeria indicate that probably postkinematic melt-rock reactions took place in the shallow SCLM beneath the southern limb of the Betic-Rif-Tell orogenic belt during the latest Neogene geodynamic evolution of the westernmost Mediterranean.

This research has been funded by a FP7-IRSES Marie Curie Action under Grant Agreement PIRSESGA-2013-612572.

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REWORKING OF ARCHEAN MANTLE IN THE NE SIBERIAN CRATON BY CARBONATITE AND SILICATE MELT METASOMATISM

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The Obnazhennaya kimberlite in the NE Siberian craton hosts a most unusual xenolith suite, equilibrated at 1.6–2.8 GPa and 710–1050°C, with common rocks rich in pyroxenes and garnet, and no sheared peridotites (Ionov et al., 2018). The refractory peridotites have Re-depletion Os isotope ages of 1.8–2.9 Ga (Ionov et al., 2015). The peridotites show significant scatter of Mg# (0.888–0.924), Cr_2O_3 (0.2–1.4 wt.%) and high NiO (0.3–0.4 wt.%). None are pristine melting residues. Low-CaO-Al_2O_3 ($\leq$0.9 wt.%) dunites and harzburgites are melt-channel materials. Peridotites with low to moderate Al_2O_3 (0.4–1.8 wt.%) usually have CaO > Al_2O_3, and some have pockets of calcite texturally equilibrated with olivine and garnet. Such carbonates, exceptional in mantle xenoliths, provide direct evidence for modal makeover and Ca and LREE enrichments by ephemeral carbonate-rich melts. The mantle lithosphere beneath Obnazhennaya has been profoundly modified. Peridotites rich in CaO and Al_2O_3 (2.7–8.0 wt.%) formed by reaction with silicate melts. More recently were formed carbonate-phlogopite pockets, fine-grained pyroxenite veins and spinel-pyroxene symplectites with REE patterns in cpx mimicking those of garnet. The reworked lithospheric sections are preserved at Obnazhennaya, but similar processes could erode lithospheric roots in the SE Siberian craton (Tok: Ionov et al. 2005) and the North China craton, where ancient melting residues and reworked garnet-bearing peridotites are absent. The modal, chemical and Os-isotope compositions of the Obnazhennaya xenoliths produced by reaction of refractory peridotites with melts are very particular (high Ca/Al, no Mg#-Al correlations, highly variable Cr, low $^{187}Os/^{188}Os$, continuous modal range from olivine-rich to low-olivine peridotites, wehrlites and websterites) and distinct from those of fertile lherzolites in off-craton xenoliths and peridotite massifs. These features argue against the concept of ‘refertilization’ of refractory peridotites by mantle-derived melts as a major mechanism to form fertile to moderately depleted lherzolites in continental lithosphere. The Obnazhennaya xenoliths represent a natural rock series produced by ‘refertilization’, but include no rocks equivalent in modal, major and trace element to the fertile lherzolites. This study shows that ‘refertilization’ yields broad, continuous ranges of modal and chemical compositions with common wehrlites and websterites that are rare among off-craton xenoliths.

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PETROLOGY OF ULTRAMAFIC ROCKS OF THE MERSIN OPHIOLITE, SOUTHERN TURKEY; DECIPHERING MANTLE-WEDGE PROCESSES

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Depleted chemical character and orthopyroxene-rich lithology may characterize the mantle wedge on the basis of arc derived ultramafic xenoliths (Arai et al., 2007; Arai & Ishimaru, 2008): sub-arc mantle xenoliths frequently contain secondary orthopyroxene (± plagioclase and quartz) replacing olivine in depleted harzburgites (e.g., Arai & Ishimaru, 2008). However, it is not easy to build a petrological model of mantle wedge based on xenoliths, because xenoliths are so limited in size (< 1 m) and fragmentary that relationships between rocks are sometimes difficult. Peridotite massifs including the mantle section of ophiolite are therefore a powerful implement to understand what kind of lithologies comprising uppermost mantle and their relationships in addition to their petrological and geochemical nature. It is important to combine the information from peridotite xenoliths with that from peridotite massifs for our better understanding of a whole picture of the sub-arc mantle. Mersin ophiolite, southern Turkey, shows an oceanic lithospheric section (approximately 6 km thick) except for absence of sheeted dykes (Parlak et al., 1996). According to the geochemical nature of effusive rocks (tholeiitic basalt), mafic-ultramafic cumulates, and dolerite dikes cross-cutting the entire ophiolite sequence (e.g., Parlak et al., 1995, 1996). The Mersin ophiolite has been known as a supra-subduction zone-type ophiolite (Dilek & Furnes, 2014), possibly has the strongest arc affinity of all Turkish ophiolites. However, details of residual peridotite, e.g., geochemical and petrological descriptions, have not been well established. We collected samples from a sequence of layered ultramafics (clinopyroxenite–wehrlite–dunite) to mantle harzburgite through MTZ dunite–wehrlite. High Fo content of olivine (Fo90-91), Cr# (= Cr/(Cr + Al) atomic ratio) of chromian spinel (up to 0.77), and low rare earth element (REE) concentrations of clinopyroxene and orthopyroxene of the mantle harzburgite indicate that it is a residue of a high degree of melting (~35%) with some influx, which rich in H_2O, light REE (LREE) and large ion lithophile elements (LILE). The calculated melts in equilibrium with clinopyroxene of layered ultramafics and MTZ dunite show similar REE pattern with boninite. Our results support its supra-subduction zone origin, and the ultramafic rocks record an evolutionary process of the lithosphere from oceanic to mature arc.

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LOCALIZATION OF DEFORMATION: THE ROLE OF METASOMATISM AND MINERAL MODE IN AN OCEAN-CONTINENT TRANSITION

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A remnant of an ocean continent transition (OCT) in the Alps (Totalp-Platta, Switzerland) offers an exceptional exposition of the upper mantle across the section. We characterized the chemical and microstructural variations induced by melt/fluid percolation and localization of deformation across the entire section. The OCT is made of spinel peridotite (Totalp) and changes toward the ocean to pyroxenite-poor peridotites that equilibrated in the plagioclase stability field (Platta). Platta contains clinopyroxene (cpx) with a L-REE strongly depleted trace elements signature similar to cpx from the abyssal peridotites. However, flat and generally enriched REE patterns of other cpx from both Platta and Totalp suggest fertilization of the peridotite by melt. Moreover, the peridotite contains amphibole (kaersutite) testifying the presence of fluid at high temperature, print of primary metasomatism. A second generation of amphibole (pargasite) undeformed and replacing cpx probably crystallized during a late fluid percolation in the peridotite. Mylonitic peridotite is observed both in Platta and Totalp and the peridotite contains µm ultramylonitic bands forming a high temperature foliation. The µm ultramylonitic bands are made by olivine (ol) + orthopyroxene (opx) or ol + cpx. The ductile deformation recorded by olivine in the host peridotite indicates a (001)[100] slip system, whereas in each µm ultramylonites a different olivine slip system is activated ([100](010) and [001](010)) while all developed under similar metamorphic conditions (750-775°C, 525-575 MPa). These results show that the activated slip system in olivine could be dependent of the mineral mode. Close to the continent (Totalp) centimetric ultramylonitic shear-zones are slightly discordant to the foliation. They are well mixed 5-mineral ultramylonite made by ol, cpx, opx, spinel and a high proportion of kaersutite (14%). The kaersutite is enriched in K_2O and clinopyroxene is enriched in Al_2O_3 and TiO_2 compared to the host peridotite and other µm ultramylonitic bands, suggesting that shear zones are the final deformation localizing an evolved melt. In the 5-mineral ultramylonite, olivine shows an axial [010] fabric and the amphibole a [001](100) fabric. Our observations suggest that the olivine [010] fabric has been promoted by a high proportion of melt. During mantle exhumation in an OCT, the deformation mechanisms activated during plastic deformation in these samples are not only dependent on the conditions of deformation (temperature, stress, strain, water content) but also on modal composition, grain size and shape of the minerals.

MULTISTAGE MANTLE METASOMATISM DURING THE GENERATION OF KIMBERLITE MELTS: EVIDENCE FROM GARNET PERIDOTITE XENOLITHS AND MEGACRYSTS, GRIB KIMBERLITE PIPE, ARKHANGELSK DIAMOND PROVINCE, RUSSIA

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Major and trace element compositions coupled with Rb–Sr and Sm–Nd data from garnets, clinopyroxenes and phlogopites sampled from the peridotite xenoliths and megacryst suite of the Grib kimberlite pipe, Arkhangelsk diamond province, Russia, suggested the following sequence of metasomatic events associated with the generation of kimberlite melts. 1. The interaction of asthenospheric melts with the subcontinental lithospheric mantle (SCLM) generated REE-enriched proto-kimberlite melts containing significant amounts of carbonate and Fe–Ti components that metasomatised the surrounding mantle rocks during their evolution and ascent. At this stage, high-Ti garnets and low-Mg# clinopyroxenes were generated. The equilibrium P–T conditions obtained in this study for the above mentioned minerals (1,150°C–1,260°C and 70 kbar) corresponded to those expected at the base of the SCLM (approximately 180–210 km). 2. The kimberlite melts interacted with the SCLM during their continued ascent, which generated Fe–Ti-rich megacrysts, such as ilmenite, garnet and clinopyroxene. Presumably, the generation process took place from the base of the SCLM to depths corresponding to pressures of 4–5 kbar. 3. Following the generation of Fe–Ti-rich megacrysts (or, possibly, immiscible Fe–Ti oxide melts), the composition of the kimberlite melts became more silicate-bearing and Fe–Ti depleted, which generated mantle metasomatism thereby transforming mantle peridotite into garnet lherzolite and forming high-Cr clinopyroxene megacrysts. At this stage, the kimberlite melts were enriched in K and $H_2O \pm CO_2$ that led to the generation of phlogopites during the pseudomorphism of the garnet grains. The P–T conditions at this metasomatic stage ranged from 3–5 GPa and 730°C–1,070°C. Much of the kimberlite melt volume was either completely consumed by the metasomatic reactions with the mantle peridotites, mainly in the lowest part of the SCLM, or crystallised around detectible mid-lithospheric discontinuities and, hence, did not reach the surface. These multiple metasomatic episodes focused on structurally weak zones that acted as transport channels for the melts. Subsequent batches of melt captured and brought the xenoliths to the surface, i.e. the metasomatised products from previously failed melt batches. Different stages of mantle metasomatism overlapped each other, which led to a complex geochemical zonation in studied minerals.

Ca-METASOMATISM DURING SERPENTINIZATION IN EXHUMING MANTLE ROCKS WITHIN THE CLOSING TETHYS: THE CASE OF RODINGITE DYKES INTRUDING OLISTOSTROMATIC ULTRAMAFIC BODIES OF KIMI FLYSCH, EVIA ISLAND, GREECE.

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In Kimi area (Evia Island, Greece) the Maestrichtian-Paleocene flysch consists of clastic sedimentary rocks, as well as olistostromes of limestones and serpentinized peridotites associated with rodingite, ophicalcite, talc schists and red mudstones. The serpentinized ultramafic rocks are intruded by rodingite dykes of gabbroic origin. Their main mineralogical assemblage comprises garnet [(hydro)grossular] + diopside + chlorite + vesuvianite. The presence of late calcite in some dykes, define another rodingite group formed during a second metasomatic event of higher XCO_2 conditions. Accessory minerals include relict spinel, prehnite, epidote, apatite, allanite, amphibole, dolomite, quartz and opaque Fe-Ti oxides. During rodingitization, which was an alkaline process strongly related to serpentinization, three distinct concentric zones of different mineralogical assemblages within the rodingite dykes were formed, whereas towards serpentinized peridotites, two zones of successive chloritite and metasomatized serpentinite were also developed. The rodingite zones correspond to gradual fluid infiltration with water/rock ratio and CO_2/H_2O ratio increasing and T decreasing towards their cores. Intense CaO enrichment and silica-alkali depletion can be attributed to clinopyroxene dissolution during serpentinization and anorthite breakdown respectively. Vesuvianite was mostly crystallized at a late stage of the first metasomatic event from Ca^{2+}- and OH^--rich fluids at low CO_2/H_2O ratio. The second metasomatic event was realized during exhumation of the rodingites and the associated ultramafics. It was concurred with the ophicalcite formation under brittle conditions, lower T and fluids with higher CO_2 content. Significant LREE enrichment, which is related to apatite and allanite especially in carbonated rodingites, could be indicative of the presence of carbonic-LREE complexes in the metasomatic fluids. Zr mobility could also support the presence of PO_4^{3-}-LREE and LREE-OH^- complexes. Stable C and O isotopes in calcite crystals from rodingite, ophicalcite and red mudstone, exhibit a combination of hydrothermal and seawater participation in metasomatic fluids. The metasomatic processes possibly took part in a SSZ setting within the closing Vardar Ocean during Upper Cretaceous. The closure of this oceanic basin coincides with the deposition of Kimi flysch and the olistostromatic incorporation of the rodingite-bearing ultramafics. Finally, a westward thrusting of the whole clastic sequence onto the Pelagonian platform was taken place during Paleocene.

DUNITES AS CHANNELS OF BONINTE MELT AT THE BASE OF THE OCEANIC LITHOSPHERE: EVIDENCE FROM THE TROODOS OPHIOLITE, CYPRUS

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Dunites, most abundantly occurring at the oceanic mantle-crust transition zone, may form either by olivine crystal accumulation in magma chambers or by interaction of basaltic melts with the uppermost mantle harzburgites, resulting in dissolution of orthopyroxene. In the Troodos ophiolite, Cyprus, hundreds of meters thick dunite 'provinces' occur above mantle peridotites and are topped by layered ultramafic and mafic cumulates. This study focuses on hitherto unreported interstitial clinopyroxene (≤2%) in Troodos dunites, as a key feature to understand their origin in the Troodos ophiolite and elsewhere. The textural styles of clinopyroxene in Troodos dunites, from isolated crystals through vein-like trails of crystals to poikiloblasts, all characterized by cuspate contacts with matrix olivine, suggest that it crystallized from melt flowing through reaction-induced porosity. The REE composition of interstitial clinopyroxene together with the major element compositions of olivine and spinel constrain the nature of melts that equilibrated with dunites while ascending to the crust. The high -Mg and low–Ti contents and spoon-shaped REE pattern of interstitial clinopyroxene in dunites are indicative of equilibration with boninite rather than with tholeiite melts. This is in line with the occurrence of a boninite suite at the top of the volcanic section and of boninitic dikes and boninite-derived plagiogranite in the middle crust of the Troodos ophiolite. Nonetheless olivine Mg# in Troodos dunites (0.88-0.91) is either equal or lower than that of associated harzburgites (0.91-0.92) suggesting that some of them formed by crystal accumulation. It is here suggested that the main dunite bodies in Troodos are relicts of channels of melt that flowed along the rheological boundary between the asthenosphere and the lithosphere, and at the base of the crust at the proximity of the spreading axis. During this migration the melt dissolved orthopyroxene in the host harzburgite and formed a dunite melt channel. Some dunites may also acquire characteristics of cumulates due to melt ponding along the rheological boundary. The interstitial clinopyroxene bears the geochemical signature of boninites, the most depleted melts characteristic of the latest evolutionary stage of the Troodos supra-subduction zone spreading center.

DOI:10.19276/plinius.2018.03015 PLINIUS n. 44, 2018

THE CHEMICAL COMPOSITION OF METASOMATIC MELTS IN THE DEEP LITHOSPHERIC MANTLE: EVIDENCE FROM MARID MANTLE XENOLITHS

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Mantle metasomatism caused by migrating fluids or melts is a common process both in shallower and deeper parts of the Earth's mantle. Whilst the effects of metasomatic fluids or melts on peridotite has been documented by numerous studies (e.g., Yaxley, 1991), the nature of the metasomatic agents often remains unclear. This is due to the fact that metasomatic fluids or melts are known to be very reactive (Green, 1988} and their interaction with peridotite minerals can cause growth of new mineral phases (Yaxley, 1991} and alternatively the melt may be completely consumed by metasomatic reactions. It is commonly assumed that either volatile-rich alkali silicate melts or alkali-rich carbonatite melts are the most common metasomatic agents in the mantle (O'Reilly, 2013). This notion is supported by the presence of Na and K-rich newly formed metasomatic minerals, such as mica or amphibole. Furthermore, mantle metasomatism goes together with enrichment of incompatible trace elements such as the REE or the large ion lithophile elements (LILE) such as Ba or Rb. It has been suggested that metasomatic reactions enrich the mantle peridotite with incompatible elements, which, ultimately, contributes to the formation of volatile- and alkali-rich volcanic rocks such as kimberlite (type I) or lamproite (e.g., Tappe, 2008). Recently, it was proposed that orangeites (or type II kimberlite) can also be products of melting of metasomatized peridotite (Giuliani, 2015). To shed further light on the chemical and mineralogical nature of the metasomatic reactions in the deep lithosphere, we set out to study a suite of mica- and amphibole-bearing mantle xenoliths from South African kimberlites. The samples show different degrees of metasomatic overprint. We analyzed all mineral phases both for major and trace elements using EMPA and LA-ICPMS. From our results, we calculated the metasomatic net flux both in terms of major and trace elements. The results enable us to identify the chemical nature of metasomatic agent, which was responsible for the formation of mica, amphibole, and Fe-Ti oxides in the deep subcontinental lithospheric mantle.

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PETROGENETIC CONSTRAINTS ON THE ORIGIN OF THE HELLENIC TRIASSIC RIFT AND SUBDUCTION-RELATED VOLCANICS

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Oceanic Triassic volcanic rocks are widespread over mainland Greece. Triassic magmatism has been interpreted of having occurred during the rifting and development of a Tethyan oceanic basin, as the Apulia and Pangea continents spread apart. It comprises of rift-related volcanics (OIB and E-MORB basalts) and of arc volcanics (IAT or calc-alkaline) [e.g. 2-8]. The geochemistry of the OIB alkaline basalts indicates that they originated from the same mantle source but were affected in many cases by differentiation. They range from undersaturated alkaline basalts (Saturation Index SI -22.0 to -8.0) to differentiated trachybasalts and basaltic trachyandesites (SI -6.0 to 1.5). Differentiation is also noticed by their highly variable Mg# (e.g. Koziakas 46.0-71.5; Evia 46.2-69.0; Othris 36.5-61.5). These rocks are sodic ($K_2O/Na_2O \approx 0.3$) and are enriched in LREE [$(La/Yb)_{PM} \approx 6.0$-17.0], displaying moderate to steep HREE [$(Dy/Yb)_{PM} \approx 1.2$-1.7]. They exhibit rather low La/Nb (Avg.≈0.7) and similar to the average HIMU-OIB Zr/Nb (Avg.≈3.6). E-MORB volcanics include both alkaline and subalkaline tholeiitic basalts. Many of the E-MORB basalts were also affected by differentiation, ranging from undersaturated basalts (SI -15.0 to -6.0) to differentiated trachybasalts and basaltic trachyandesites (SI -4.0 to 14.5). The extent of differentiation is noticed by their highly variable Mg# (e.g. Koziakas 33.0-66.5; Evia 58.0-65.0; Pindos 59.0-67.0; Attica 47.0-66.0; Othris 54.0-80.0; Argolis 50.5-70.0). They are sodic ($K_2O/Na_2O \approx 0.2$) and compared to OIB basalts are less enriched in LREE [$(La/Yb)_{PM} \approx 1.6$-7.5], but present slightly lower HREE [$(Dy/Yb)_{PM} \approx 1.1$-1.3]. They exhibit higher La/Nb (Avg.≈0.9) and Zr/Nb (Avg.≈7.4). Subduction-related high-Mg mafic IAT lavas are fairly enriched in LREE [$(La/Yb)_{PM} \approx 1.6$-4.6] displaying comparable HREE [$(Dy/Yb)_{PM} \approx 0.9$-1.3] with E-MORB lavas. However, their La/Nb (Avg.≈4.3), Zr/Nb (Avg.≈29.8) and mineral chemistry associate these rocks with subduction. Various geothermobarometers were applied upon the least differentiated OIB and E-MORB basalts. Mantle potential temperatures are estimated at ~1450 °C and ~1410 °C respectively (melt fraction of ~5% from a garnet peridotite source). The hydrous primary magma of the IAT basalts is estimated to have been formed at high temperature (>1300 °C) melting conditions for arc settings, which can possibly be attributed to subduction of an infant and presumably hot oceanic lithospheric slab.

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WATER AND ITS DISTRIBUTION IN THE UPPER MANTLE BENEATH THE PANNONIAN-BASIN: GEODYNAMICAL AND GEOPHYSICAL IMPLICATIONS

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‘Water’ plays a crucial role in influencing the melting relations and phase assemblage of the upper mantle. Recent studies demonstrated that even trace amount (few hundreds of wt.% ppm H_2O) could drastically lower the melting temperature (~by 200 °C with respect to the dry solidus) of the shallow upper mantle causing the formation of incipient partial melt (Green et al., 2010; 2014; Kovács et al., 2012). The stability of a hydrous phase (i.e. pargasitic amphibole) has a particularly important role in regulating the water storage capacity and melting temperature of the shallow upper mantle (<~90 km). In particular in these shallow depths the upper mantle melts at the pargasite dehydration solidus (at ~ 1050 °C) even if the bulk ‘water’ content is very low (~200 ppm) which is typical even in depleted middle ocean ridge upper mantle. It follows that the shallow upper mantle melts at ~ 1050 °C even at very low bulk water contents (~ 200 ppm). This has two very important verifiable geodynamics consequences: 1) The 1050 °C isotherm beneath young continental rift areas and oceanic basins should in most cases coincide with the lithosphere-asthenosphere boundary; 2) The asthenosphere in these tectonic environments should have at least small amount (<1 v/v%) incipient melt present. The Pannonian Basin, a young (< 20 Ma) continental extensional basin, is an excellent natural laboratory to test these verifiable assumptions. In our presentation we will demonstrate based on surface heat flow data, and ‘water’ contents in clinopyroxene phenocrysts of alkaline basalts from the area that these predictions of the theory appears to be in line with observations (Kovács et al., 2017). In addition it will be presented, how the ‘water’ content of nominally anhydrous minerals (NAMs) in upper mantle peridotites varies between the central and marginal areas of the Pannonian Basin. We will demonstrate, how the concentration, speciation and partitioning of ‘water’ change in NAMs in the more extended central and less extended marginal parts of the Pannonian Basin.

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A NEW SITE WITH A LARGE CENOZOIC MANTLE XENOLITH-RICH NEPHELINITE DYKE IN SOUTHERN POLAND (OPOLIAN SILESIA)

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A large new dyke has been identified at the Folwark quarry, near Opole in the south of Poland, where Cretaceous marls are exploited. No basaltoid has been reported from this location yet. The Folwark dyke, which runs NE–SW, is located about 26 km E from the Gracze melabasanite quarry, 17 km E from the Ligota Tułowicka site, and 26 km NW from the Góra Świętej Anny melanephelinite site. The dyke does not reach the present erosional level. The upper surface of the dyke, which is the only accessible part of this subvolcanic body, has been exposed at the boundary of the Turonian and Coniacian deposits. It is over 200 m long (with terminations that do not crop out, but run into the quarry walls) and from 10 to 35 cm wide. The rock is grey and does not show macroscopically noticeable alternations. Mostly secondary calcite-filled round pores (0.3–5 mm in diameter) are very numerous in the rock. Although the calcite-free fragments were handpicked for bulk chemical analysis, some tiny calcite remnants may have influence the chemical composition-based name of this rock; most likely, however, the rock can be classified as nephelinite. It consists of clinopyroxene, olivine, nepheline, and spinel crystals. The clinopyroxenes (Ca-rich diopside; mg# 70–78) are the most abundant constituents of the groundmass, but phenocrysts (0.9–0.3 mm) are rare. Among the olivines (up to 2.6 mm in diameter), phenocrysts (Fo ~86) abundant in the groundmass and xenocrysts (Fo ~ 91) less numerous than cpx are recognized. Cr# values in the spinels are ~20. Very abundant xenoliths (<1–5 cm in diameter) are present in the examined nephelinite. They mainly represent the mantle ultramafic rocks (dunite, harzburgite, wehrlite). Some xenoliths have been altered and, in several cases, their primary minerals have been replaced by the secondary calcite. Some xenoliths of crustal origin have also been identified. (The preliminary results of the K–Ar dating point to the Oligocene origin of the dyke.) To the best of our knowledge, we are reporting here for the first time on a subvolcanic body from the easternmost part of the Central European Volcanic Province, with very numerous mantle xenoliths.

Investigation continues and is partly financed by the NCN grant 2014/13/B/ST10/02102 and UAM funds.

DOI:10.19276/plinius.2018.03015

MANTLE ROCK-DERIVED PYROPES AS DETRITAL MATERIAL IN THE LOWER TRIASSIC ARENITES FROM THE NE FORELAND OF THE BOHEMIAN MASSIF: FINDING THE HOST ROCKS

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Numerous pyrope grains (63–250 µm in diameter) were found in the Świerklaniec Beds (Older Buntsandstein, Lower Triassic) from the Opolian Silesia in southern Poland (NE foreland of the Bohemian Massif (BM)). This is the first find of numerous detrital pyropes outside, but in close proximity to, the BM, as well as the first from the Lower Triassic deposits. Hitherto, detrital pyropes have been known from few sites within the BM, such as from the Quaternary deposits of the Saxothuringian Zone (SZ), and such pyropes are believed to be recycled from the 'certain' (undefined) horizons of the Carboniferous–Permian and Cretaceous deposits. Moreover, some relicts of C–P and K deposits from the Moldanubian Zone (MZ), as well as from small units contiguous to the MZ, also contain pyrope grains. The examined detrital pyrope-bearing quartz arenites are aeolian deposits. Their heavy mineral assemblages consist of zircon, tourmaline and rutile grains (values of ZTR index range from 30 to 80), accompanied by garnet and other grains. The pyropes examined here ($Prp_{62-72}Alm_{14-24}Grs_{(<1)4-14}Uv_{(1)2-14}Sps_{<1-1}Adr_{<1-2}$; n=333) are the most frequent of the other four distinguished groups of garnets. Comparative analysis reveals that the pyropes are quite a heterogeneous population, and may have been derived from various primary host rocks. In several discriminative diagrams, they occupy fields of (1) mantle-derived garnets, (2) lherzolite, and low Cr rock-derived garnets, and (3) lherzolite, pyroxenite, low-Cr megacrysts, and eclogite-derived garnets. Regarding the crystalline rocks that crop out at the present erosional level of the BM, the most comparable chemical compositions show garnets contained in the type III peridotites (subcontinental variety) exposed in the MZ (Nové Dvory, Hamry), the Kutná Hora Unit (Bečváry, Úhrov, Ratbor), and to a lesser extent in the SZ (the Granulitgebirge). The examined pyropes are faceted, and show signs of abrasion and fragmentation, which suggests (multiple?) recycling from some sedimentary rocks. However, no older or coeval sedimentary rocks from the BM or the adjacent areas contain either comparable garnets groups or pyropes of comparable chemical compositions. The central and eastern parts of the BM are possible alimentary areas for some unknown Permian–Lower Triassic secondary source rocks, which must have been destroyed in the past. This research was financed by NCN grant 201/13/B/ST10/02102.

DOI:10.19276/plinius.2018.03015

PRELIMINARY DATA ON MANTLE XENOLITHS FROM ALLEYRAS (DEVÈS VOLCANIC FIELD, FRENCH MASSIF CENTRAL)

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Mantle xenoliths are common in Cenozoic lavas of French Massif Central. Lenoir et al. (2000) distinguished two lithospheric mantle domains beneath Massif Central, a depleted one to the north of 45º30'N latitude and a less depleted one to the south. The Devès volcanic field is located in the southern domain. In this abstract we present the data from 6 xenoliths from Alleyras, which are hosted by an analcime basanite. The xenoliths are up to 10 cm in size (Coisy, 1977, reports sizes up to 15 cm). They are mostly spinel lherzolites with porphyroclastic textures, except sample 3763, which is a protogranular spinel harzburgite. The largest grains (porphyroclasts) are usually those of orthopyroxene. Olivine contains from 89.5 to 90.5 % of forsterite, except harzburgite 3763, in which olivine is Fo90.6-91.0. Orthopyroxene (Mg# 0.90 – 0.91) shows significant variation in Al contents - from 0.07 to 0.18 atoms of Al pfu (per formula unit). The orthopyroxene from harzburgite is Al-poor (0.08-0.10 atoms pfu). Clinopyroxene (Mg# 0.90-0.92) is aluminous: it contains 0.24-0.30 atoms of Al pfu. Spinel is aluminous (Cr# 0.10-0.12) except that occurring in harzburgite (Cr# 0.46). The clinopyroxene REE contents are slightly (1-10 x) enriched relative to primitive mantle. The REE patterns show impoverishment from HREE towards LREE. The exception is harzburgite, which shows a LREE enriched pattern with well-defined negative anomalies of HFSE. Lherzolites, which are fertile in terms of mineral chemical composition, are typical of the southern mantle domain of Massif Central. The temperatures of cpx-opx equilibration (Brey and Köhler 1990) typically range 750 to 800 ºC for lherzolites. They correspond to the group A defined by Uenver-Thiele et al. (2017). Harzburgite exhibits characteristics which similar rather to that of northern mantle domain. Greater population of samples must be studied to understand better the relationships between fertile and depleted peridotites in Alleyras. Funding: This study was possible thanks to the project NCN UMO-2014/15/B/ST10/00095 of Polish National Centre for Science to JP.

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HARRISITIC-LIKE TEXTURE BEARING XENOLITHS FROM THE ČAMOVCE QUARRY, NÓGRAD-GÖMÖR VOLCANIC FIELD

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The Nógrád-Gömör (Novohrad-Gemer) Volcanic Field is one of the monogenetic volcanic areas within the Carpathian-Pannonian-region, which is Pliocene-Pleistocene in age. The alkaline basaltic melts bought abundant amount of crustal and mantle xenoliths to the surface and numerous studies of these xenoliths were carried out for understanding the activity and evolution of the area (eg. Kovács et al. 2005; Liptai et al., 2017). One of the localities where abundant amount of crustal xenoliths (for example granite, syenite, sandstone) occur, is the *Čamovce* quarry, where the age of the volcanic activity is dated around 5.2 Ma. Within the xenoliths a few, up to 6x6x2 cm big harrisite-like rocks have been found that have a macroscopically white and brown coloured layering, where both type of layers are 1-5 mm thick and have a fine grained texture, besides crustal xenolith without layering can also be found. Within the thin section no contact aureola can be seen around the xenoliths. The brown layers consist mainly of olivine, clinopyroxene with minor hercynite spinel and plagioclase, while the white layers are mostly made of plagioclase (~90%) with minor hercynite spinel, opaque minerals, olivine and pyroxene. The plagioclase dominant layer forms an equigranular texture, while the olivine crystals within the olivine and clinopyroxene dominant layer form an unoriented, dendritic, harrisitic-like texture. The boundary of the olivine and clinopyroxene rich layer often adjust to tabular crystal shapes, but inside these shapes only xenomorphic plagioclase crystals can be found. The width-length ratio of the skeletal olivine crystals are mostly around 1:20, but in some cases it goes up to 1:40. The clinopyroxene surrounds the olivine and occurs as skeletal crystals too. Hercynite spinel forms angular, rounded crystals and occurs sporadically in the olivine and clinopyroxene dominant layers. A sharp boundary can be seen between the olivine and hercynite spinel, while this type of boundary is missing between the clinopyroxene and hercynitic spinel. Besides petrography we also carried out EPMA, LA-ICPMS and FTIR study. Combining the given results we think that the harrisite-like texture rocks represent a multistage evolution and could play a significant role in understanding the volcanic evolution of the Nógrád-Gömör Volcanic Field.

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RECONSTRUCTING GEOCHEMICAL AND DEFORMATION EVENTS IN MANTLE XENOLITHS FROM THE NORTHERN PANNONIAN BASIN

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Spinel lherzolite xenoliths were studied from the Nógrád-Gömör Volcanic Field (NGVF), located in the northern part of the Pannonian Basin, a young back-arc basin with a complex Neogene tectonic history. The NGVF is one of the five key localities in the Carpathian-Pannonian region where mantle xenoliths are hosted in late Miocene to Pleistocene alkali basalts. A suite of 50 samples was examined in this study to reveal geochemical processes, recent deformation events, and the possible links between them. Geochemical analyses revealed imprints of multiple metasomatic events, identified by Mg-numbers of olivine and REE concentrations of pyroxenes, that affected a heterogeneously depleted lithospheric mantle (Liptai et al., 2017). These events include (1) formation of Nb-poor amphibole by reaction with subduction-related volatile-bearing silicate melts/fluids, (2) metasomatism by a mafic melt of intraplate origin, resulting in enrichment of U-Th-(Nb-Ta)-LREE in clinopyroxene and formation of Nb-rich amphibole, and (3) the youngest melt-rock reaction, causing enrichment in Fe, Mn, Ti and LREE and overprinting older geochemical signatures.The xenoliths display varying physical properties depending on their depth of origin: shallower (lower-temperature) layers have fine-grained textures and relatively dispersed crystal preferred orientation, whereas deeper layers are coarse-grained and have stronger fabrics. The latest observable deformation of the lithospheric mantle of the NGVF occurred in a dominantly transpressional regime, following the Miocene extension of the Pannonian Basin. This regime was linked to the convergence of the Adria microplate and the European platform, and produced recent mantle structures in sublithospheric layers, inferred from the observed high seismic anisotropy. Deformation effects are overprinted by annealing in all xenoliths, resulting in decreasing intragranular deformation from north to south within the NGVF. Although there is no direct correlation between fabric properties and geochemistry, annealing is most probably linked to the presence of metasomatizing melts in the upper mantle prior to entrainment of the xenoliths in the host basalt. The latest metasomatic event is detectable in higher equilibration temperatures and Fe-enrichment of xenoliths in the central part, suggesting that the heating effect of this melt was still active during the time of sampling by the host magma.

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MULTIPHASE SOLID INCLUSIONS IN GARNET-PERIDOTITE FROM THE ULTEN ZONE (EASTERN ALPS, ITALY)

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Inclusions in peak minerals are commonly considered records of pre-peak or peak conditions, preserved by the armouring effect of the porphyroblast. They can consist of an association of different minerals (multi-phase solid inclusions) resulting from fluid-rock interaction (Frezzotti & Ferrando, 2007). In this study, we focussed on garnet inclusion mineralogy from a peridotite of the Ulten Zone, a remnant of Variscan basement entrained in the Alpine belt during Tertiary, involved in a multi-stage metasomatism (Scambelluri *et al.*, 2010). We used multi-phase solid inclusions as a tool to reconstruct the metasomatic history. The studied sample shows a garnet porphyroclast surrounded by a kelyphitic corona wrapped by a fine-grained matrix of olivine, amphibole, orthopyroxene, clinopyroxene and spinel. Low-Cr spinel surrounds high-Cr spinel. Accessory minerals in the matrix are dolomite, apatite, and sulfides. Dolomite is interstitial between matrix minerals or associated with amphibole and spinel in kelyphite. Garnet is highly fractured and cracks, filled by chlorite and amphibole, testify fluid-rock interaction. Garnet also hosts abundant randomly distributed single and multi-phase solid inclusions. Single inclusions are amphibole, chlorite, spinel, apatite and dissakisite-(La), i.e. an REE-bearing epidote (Tumiati *et al.*, 2005). Multi-phase solid inclusions have variable mineral associations. The most abundant are spinel-bearing and amphibole bearing-multiphase solid inclusions. In the former high-Cr spinel is surrounded by amphibole, locally associated with dolomite and kinoshitalite (i.e. a Ba-rich phlogopite). In the latter amphibole can be associated with dissakisite-(La), apatite, dolomite, calcite, spinel, sapphirine, chlorite, kinoshitalite, and sulfides. Low-Cr spinel is associated with amphibole and replaced by sapphirine. By integrating textural analysis, mineral-chemistry and geothermobarometry, two metasomatic events could be constrained, the first occurring near peak conditions (≈ 850 °C) and the second below 800 °C. REE- and LILE-rich fluids infiltrated into garnet cracks and reacted with garnet generating multi-phase solid inclusions. Thus, multi-phase solid inclusions can record metamorphic evolution occurring even after garnet growth, i.e. during exhumation.

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UHP TI-CHONDRODITE IN THE ZERMATT-SAAS SERPENTINITE: CONSTRAINTS ON A NEW TECTONIC SCENARIO

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Zermatt-Saas serpentinites in Valtournanche are characterized by a dominant S2 HP-UHP foliation, defined by Ol+Cpx+Ti-Chu+Chl+Atg+Mag (Rebay *et al.*, 2012 and 2018). A detailed structural survey (1:20 scale) of selected outcrops preserving this syn-D2 paragenesis, together with microstructural analyses, has allowed to recognize relationships between D2 and pre D2 mineral and structural relics, preserved in centimetre- to metre-sized domains wrapped by S2. Pre-D2 mineral assemblages consist of Cpx or Ol + Ti-Chn + Spl porphyroclasts + Atg ± Chl. Ti-Chn + Ti-Chu polygonal aggregates (with minor Chl + Ilm + Mag + Atg + Cpx or Ol) can be interpreted as either predating S2 or being synkinematic with the early stages of S2 development (pre-D2 to early D2). The occurrence of Ti-chondrodite and/or Ti-clinohumite indicates that these rocks re-equilibrated at UHP conditions (P = 2.8–3.5 GPa, T = 600–670 °C) and syn-D2 assemblages indicate P-T conditions in agreement with those already determined in the surrounding serpentinitites and rodingites ($P<2.8$, T = 580 - 620°C; Zanoni *et al.,* 2016 and refs. therein), dated at 65 ± 5.6 Ma (Rebay *et al.*, 2018). The finding of UHP peak conditions similar to the 44-40 Ma old UHP (Rubatto *et al.*, 1998) in the near Cignana Unit, where coesite in garnet (Reinecke, 1991) and microdiamonds (Frezzotti *et al.*, 2011) have been found, dramatically widen to at least 60 Ma the time interval under which ZSZ has been involved in the Alpine subduction. In addition, these results support the idea that ZSZ represents a mosaic of ophiolitic tectono-metamorphic units, which recorded different and diachronic P-T-d-t paths and that coupled together during Alpine exhumation.

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RELATIONSHIPS BETWEEN HYDROTHERMALISM, VOLCANISM AND BRITTLE DEFORMATION ALONG A LARGE DETACHMENT FAULT PRESERVED IN A FOSSIL OCEANIC CORE COMPLEX: INSIGHT FROM THE CHENAILLET OPHIOLITE

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The Chenaillet ophiolite, a well-preserved ocean floor fragment of the Alpine Tethys (Chalot-Prat, 2005), consists in basaltic volcanoes overlying tectonically exhumed gabbro and mantle peridotite as observed at a slow spreading mid-oceanic ridge. The gabbroic and peridotitic basement belongs to oceanic core complexes crosscut by several detachment faults and related high-angle normal faults striking mainly N110-N130° and dipping eastwards. New observations highlight the major role of tectonic constraints on mantle lithosphere with formation of detachment and high-angle faults, which induce in turn important fluid and magma transfers through the oceanic lithosphere up to the surface. Our tectonic analysis yields extensional stress tensors with σ_3 oriented N30°, paleostress orientations contemporaneous of extension and enlargement of the Tethyian lithosphere. In the NE part of the ophiolite, σ_1 displays similar orientation than σ_3 with low displacement on reactivated reverse faults. As attested by the cross-cutting of the 1st generation normal kinematic criteria, these reverse faults postdate the extensive regime and were reactivated during the obduction of the Chenaillet nappe. At the scale of the ophiolite, a clear segmentation between a volcanism-dominated zone in the SW and a hydrothermalism-dominated zone in the NE part of the ophiolite is observed. Detailed petrological and deformation studies were performed on a well-preserved detachment fault between a serpentinite hangingwall and a gabbro footwall. In going towards the major fault plane, deformation increases from proto- to ultra-mylonitic on the serpentine side (15 m thick) and from proto-cataclastic to micro-brecciated on the gabbroic side (5-8 m thick). Numerous quartz veins crosscut this large deformed zone, all the more numerous as they are closer and parallel to the fault plane. These sharp veins reflect first a fragile deformation event during which an important fluid circulation took place. Besides mantle serpentinization is known to release a lot of silica (10-13% SiO_2 of the whole rock). The absence of carbonate (ophicalcite) usually filling the fault planes and cracks within the mantle basement ask the question about the differences between their conditions of formation. A thin basaltic dyke is injected in the lithological discontinuity of the detachment. Dyke clasts are crushed and disseminated in the breccia implying that its injection occurred during the time span of detachment slip.

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GEONEUTRINOS FOR UNVEILING THE EARTH'S INTERIOR

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While the geophysical structure of the entire Earth is almost well established, available direct information on its composition relies on shallow drill cores and samples brought to the surface by volcanic eruptions. Breakthroughs are expected from the interplay between Earth Science and Particle Physics, through the detection of geoneutrinos (Fiorentini et al. 2007) and the promising scenarios of the Earth's spectrometry with atmospheric neutrino oscillations (Rott et al., 2015). Geoneutrinos are electron antineutrinos emitted in beta minus decays, with some from the ^{238}U and ^{232}Th decay chains having sufficient energy to be detected (Araki et al., 2005). These particles, originating from the radioactivity of the crust and of the mantle, can traverse the planet almost without interacting, therefore bringing to surface instantaneous information from the Earth's interior. By measuring their flux and energy spectrum it is possible to infer the global amount, distribution, and ratio of U and Th in the crust and in the mantle, essential ingredients for the discrimination among different Bulk Silicate Earth (BSE) compositional models (Bellini et al. 2013). Geoneutrino measurements by particle physicists can provide to geoscientists a unique probe for addressing open questions about heat production in our planet, necessary to understand the global power inside the Earth that drives plate tectonics, mantle convection, and the geodynamo.

Experimental measurements performed by the KamLAND (Japan) (Gando et al. 2013) and Borexino (Italy) (Agostini et al. 2015) experiments are opening the way to multiple-sites geoneutrino studies aimed at distinguishing the site-dependent crustal components from the mantle component (Fiorentini et al., 2012). In this framework, new geoneutrino measurements are highly awaited from the Canadian SNO+ detector (Andringa et al., 2016) and from the JUNO (An et al., 2016) and Jinping (Beacom, J.F. et al., 2016) experiments, both located in China. In the next decade, when geoneutrino data will be available for several detectors on the Earth, the subtraction of the crustal component should permit to define the range of permissible compositional models that describe the BSE.

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METASOMATIC PROCESSES IN LITHOSPHERIC MANTLE BENEATH SW POLAND

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Lithospheric mantle beneath northern parts of Bohemian Massif was intensively sampled during Cenozoic episode of volcanic activity. Around 300 outcrops of alkaline, mostly mafic volcanic rocks from this period occur in SW Poland; ~3% of them carries xenoliths of peridotitic and pyroxenitic rocks. In this study we compare 6 xenolith suites from SW Poland, described in details elsewhere (Puziewicz et al., 2015, Matusiak-Małek et al., 2017 a,b, Ćwiek et al., 2017). The xenoliths were collected mostly from Oligocene/Miocene volcanics, only one locality being of Holocene age.

Peridotites are mostly harzburgites, whereas lherzolites and dunites occur subordinately. Hydrous minerals only occur in one locality. Based on forsterite (Fo) content in olivine, peridotites have been divided into two groups: A ($Fo_{89.5-91.5}$) and B (Fo_{84-89}). The Mg# of pyroxenes follow this dichotomy; the Mg# in group A orthopyroxene and clinopyroxene are 0.89-0.92 and 0.90-0.94, respectively, while in group B it is 0.85-0.90 and 0.86 - 0.90, respectively. Clinopyroxene is always LREE-enriched, but the REE patterns change from U-shaped (group A) to convex downward (groups A and B). Regardless the REE pattern, clinopyroxene always has negative Zr, Hf and Ti anomalies and often positive Th-U anomalies. Temperatures of equilibration vary from 850°C to 1100°C; the highest temperatures are recorded in xenoliths from Oligocene volcanics suggesting intensive thermal rejuvenation at that time. Pyroxenites have cumulate texture and are characterized by low Fo (77-82) content in olivine and Mg# values in clinopyroxene (0.78-0.86) and were classified as group C. Cumulative clinopyroxene has convex downward REE pattern, but lacks negative Ti anomaly.

Lithospheric mantle beneath SW Poland suffered from significant (15- 30%) depletion in basaltic component. The mantle was subsequently affected by chromatographic metasomatism by CO_2-bearing alkaline silicate melt related to Cenozoic volcanic activity. In this model, pyroxenites represent direct precipitates from the metasomatic melt, while groups B and A record composition of mantle rocks metasomatized at decreasing melt/rock ratios. During metasomatism a secondary clinopyroxene was crystallized into the peridotites. Locally, reaction with metasomatic agent triggered formation of replacive dunites. Despite numerous local modifications, this model seems to be applicable to the entire lithospheric mantle beneath northern margin of Bohemian Massif.

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METHANE-RICH FLUIDS IN THE UPPER MANTLE ENVIRONMENT AND THEIR ROLE IN REDOX MELTING PROCESSES

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A new experimental design has been used to experimentally study the behaviour of reduced, methane-bearing fluids in the deep upper mantle environment and their potential involvement in redox-melting reactions. It is known, that strongly reduced CH_4-bearing fluids behave differently compared to more oxidized H_2O or CO_2-bearing fluids and exhibit an 'incompatible" behaviour, meaning that methane is not incorporated into mantle minerals or melts in weight percent concentrations. Therefore, such fluids have a greater chance to survive subduction or migrate through the mantle without being involved in any chemical reactions with the surrounding rock. This fact makes the presence of reduced fluids interesting in terms of potential redox-melting reactions and subsequent metasomatic interactions.

Experiments were carried out at pressures from 3 to 7 GPa and temperatures up to 1300 °C at fO_2 conditions ~0.5 log units above the Iron-Wüstite buffer [Matjuschkin et al., in revision]. Synthetized fluids were trapped in olivine and investigated using Raman spectroscopy. Results demonstrate that at such reduced fO_2 conditions, fluids consist mainly of CH_4 and small amounts of higher hydrocarbons, like C_2H_4. Interestingly, water was not found in any inclusions. On the other hand, H_2 was observed to have been incorporated in olivine, implying that H_2 must also have been present in fluid phase during the experiment. Results suggest that magmatic fluids with significant contents of CH_4 can be stable at normal pressure-temperature conditions of the upper mantle. Such fluid compositions do not require metal saturation.

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DIVING BENEATH CRATON – PRELIMINARY RESULTS ON MAFIC AND ULTRAMAFIC XENOLITHS FROM SCANIA (S SWEDEN)

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Southern Sweden (Scania region) is underlain by Proterozoic crust of East European Craton (EEC). In Mesozoic, this area was affected by rifting resultin in volcanic activity. Some of the alkali basaltoids carried peridotitic, pyroxenitic, noritic and granitoid xenoliths (Rehfeldt et al., 2007). In this study we examine the composition of mafic and ultramafic xenoliths in order to reconstruct the evolution of lithospheric mantle and lower crust beneath S-W margin of EEC. The peridotitic xenoliths are mostly lherzolites showing porphyroclastic and rarely protogranular textures. In some of the porphyroclastic xenoliths symplectitic spinel occurs. One sample is harzburgite having serial texture. Pyroxenites and norites have cumulate textures.

Porphyroclastic lherzolites have bulk rock Mg# ranging from 0.88 to 0.89 (L-Mg# samples in the following), while in the lherzolites with protogranular texture have Mg# ~0.90 (H-Mg# samples in the following). All the peridotites are enriched in LREE: the H-Mg# samples show steep REE patterns with $(La/Lu)_N$ =that vary from 19 to26), while the L-Mg# have U-shaped REE patterns ($(La/Lu)_N$=9-19).

The forsterite content (Fo) in olivine from the L-Mg# samples ranges from 90 to 91, in the in H-Mg# samples from 91 to 92, and 78 in harzburgite. The Mg# of the orthopyroxene and clinopyroxene vary from 90 to 92 and from 91 to 93 respectively whereas orthopyroxene in harzburgite has Mg#~81. The spinel Cr# in lherzolites and in harzburgite is from 0.23 to 0.32 and from 0.06 to 0.09, respectively. Olivine in norites has Fo_{55-62}; orthopyroxene has Mg#=69-72, while in clinopyroxene it is 76-79. Plagioclase in norites has composition of An_{47-57}, opaques are ilmenite.

The two pyroxene thermometer by Brey and Köhler yieds equilibration temperatures that range from 900-1000°C for the L-Mg# lherzolites and approximately 1200°C for the H-Mg lherzolites. The norites have been equilibrated by T~700°C. The low whole rock MgO and LREE enrichement of the L-Mg# samples, suggest that their composition was not shaped by partial melting (Herzberg, 2004) but by cryptic metasomatism.

The H-Mg# samples record depletion, but were also metasomatically enriched. Norites and pyroxenites may witness events of magmatic underplating. Establishing the detailed evolution of lithospheric mantle and lower crust beneath S Sweden requires further studies.

Funding: This study was possible thanks to the project NCN UMO-2016/23/B/ST10/01905 of Polish National Centre for Science.

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AN UNDEFORMED PYROXENITE-PERIDOTITE SEQUENCE FROM THE EXTERNAL LIGURIAN OPHIOLITES RECORDS MULTIPLE EVENTS OF MELT-ROCK INTERACTIONS

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The External Ligurian mantle sequences represent deep subcontinental lithosphere exhumed in response to Mesozoic lithospheric thinning and opening of the Jurassic Alpine Tethys. They mainly consist of spinel-plagioclase lherzolites, with tectonite to mylonitic structures, and diffuse pyroxenite layering. The deformed pyroxenites have been related to recycling of old crustal material in Lower Palaeozoic to Triassic times (e.g. Montanini et al., 2015; Borghini et al., 2016). The lherzolites of the present study (Monte Gavi) are undeformed and show evidence of melt infiltration and crystallization of plagioclase (Pl) + orthopyroxene (Cpx) at the expense of spinel (Spl) and clinopyroxene (Cpx). The lherzolites include a pyroxenite body with a thickness of 6-10 m and a length of ~ 50 m. The primary assemblage of the pyroxenite consists of Cpx and Al-Spl. Cpx is resorbed and variably replaced by Opx + Pl aggregates. Spl is extensively transformed into Ca-rich Pl + Fe-rich olivine + Cr-Spl ± ilmenite. Clinopyroxene has low Mg# (81-83) and up to 10 wt% Al_2O_3. Close to the main pyroxenite body, the lherzolite includes up to 10 cm-thick spinel pyroxenite layers containing Mg-rich Cpx (Mg# = 89-90) and, locally, Mg-rich olivine incorporated from the host lherzolite. REE compositions of melts in equilibrium with the preserved primary Cpx display a slight LREE enrichment and a negative HREE fractionation requiring a garnet-bearing source. The Fe-rich pyroxenite body has "melt-like" patterns of highly siderophile elements (HSE), whereas the Mg-rich pyroxenites are enriched in Os and Ir. Bulk rock $^{187}Os/^{188}Os$ ratios recalculated at the age of the Alpine Tethys opening (165 Ma) show increasingly radiogenic composition from Mg- to Fe-rich pyroxenites ($^{187}Os/^{188}Os$ = 0.185-0.518). We propose that the pyroxenites formed by crystallization of Al-Fe-rich melts derived from aged pyroxenite/eclogite-rich sources. Whereas the thick pyroxenite body represents a melt-dominated system, the thin pyroxenite layers formed by melt/peridotite hybridization. Extensive replacement of the primary assemblage was most likely produced by reactive migration of depleted MORB-type melts under plagioclase facies conditions (P ~0.6 GPa). The pyroxenites preserve high T (1200-1250 °C) recorded by slowly diffusing elements like REE, presumably in response to the melt infiltration event, followed by a rapid subsolidus cooling until 900 °C during rifting-related exhumation of the mantle sequence.

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PETROLOGY OF THE ULTRAMAFIC ROCKS IN THE TALKEETNA ARC ROOT, ALASKA

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There are many studies on arc volcanic rocks (e.g., Kimura et al., 2014) and several detailed studies of arc lower crustal sections (recent reviews in Jagoutz & Kelemen 2015). However, studies on arc mantle materials have been limited and are mainly from mantle xenoliths captured in arc volcanos (e.g., Arai & Ishimaru, 2008; Benard et al., 2017), together with studies of exposed, residual peridotite and ultramafic cumulates at the base of the Kohistan arc section in NW Pakistan (Garrido et al. 2007; Bouilhol et al 2009, 2011). The Talkeetna arc, Alaska, is an accreted arc section from volcanic sequence to mafic-ultramafic rocks (DeBari & Coleman, 1989; Kelemen et al., 2014). The lowest section of the Talkeetna arc, i.e., peridotite bodies, mainly consist of lherzolite to harzburgite with minor amounts of dunite including chromitite layers, and pyroxenites (clinopyroxenite, websterite and orthopyroxenites). We examined the petrology of these lithologies in the context of arc root evolution. Most pyroxenites are present along the contact between residual peridotites and overlying, gabbroic crust. They are interpreted as remnants of a much thicker layer of igneous pyroxenite, most of which became unstable and foundered into the mantle wedge (Jull & Kelemen, 2001; Greene et al. 2006; Kelemen et al., 2014). Locally, pyroxenites cut lithological boundaries in residual peridotites. Petrological characteristics and major element compositions of minerals in the harzburgites and lherzolites underlying the pyroxenites are consistent with their origin as residues of partial melting, fluxed by arc-related fluids/melts, followed by variable extents of reactive melt transport and melt extraction. The very sharp contacts between the host pyroxene-bearing peridotites and dunites, coupled with mineral compositions, indicate that the dunites formed by interaction with the host peridotites and the arc-related melts formed by the influx melting in conduits of focused melt transport. Ultramafic rocks are also locally found in the lowermost crustal section where gabbroic rocks are dominant. Ultramafic rocks are lherzolite to spinel websterite in compositions. Mineral zoning from green spinel-rich clinopyroxene zone at the contact with the host gabbro to orthopyroxene-rich zone in the core of small ultramafic pods in the gabbro, indicating their metamorphic origin from olivine-bearing gabbro on cooling and/or increasing pressure conditions.

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CARBONATES AND MELT-ROCK REACTIONS IN SULPHIDE-BEARING ULTRAMAFIC INTRUSIONS OF THE IVREA-VERBANO COMPLEX

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Ultramafic intrusions emplaced in the Ivrea-Verbano (I-V) Complex contain substantial amounts of volatiles including carbon in form of carbonates or graphite (Garuti et al., 2001; Locmelis et al., 2016 and ref. therein). Especially the Valmaggia ultramafic "pipe" and the pyroxenite intrusion of Campello Monti are highly enriched in carbonates intergrown with the magmatic silicate-oxide assemblage and with remarkable Ni-Cu-PGE blebby to nodular sulfide mineralization (Sessa et al., 2017). Among the I-V pipes, the Valmaggia intrusion displays impressive evidence of pervasive melt-rock reactions between a peridotitic crystal mush, or brecciated protolith, and a volatile-rich percolating melt similar to adakite. Augite oikocrysts, olivine and enstatite were extensively overprinted by pargasitic amphibole, enstatite II, phlogopite and spinel at PT conditions of 4 to 8 kbar and 700 to 900°C. The metasomatic replacement occurred along progressive reaction fronts marked by multiple coronas between the Ca-Na plagioclase-rich melt and the peridotitic assemblage. Carbonates, like sulfides, appear to be strictly related to the metasomatic assemblage. Similar carbonate-silicate assemblages also occur in sulfide-rich samples from the Campello Monti Ni mine. Carbonates are interstitial to silicates and sulfide aggregates, occasionally embedded in sulfides, and range from Fe-rich calcite, dolomite to siderite according to the nature of the associated mineral (amphibole, olivine/enstatite/phlogopite, core of sulfide nodules). At Campello Monti carbonates are also included in silicates. The origin of carbon in these intrusions is controversial: mantle degassing, carbonatite component or derivation from sedimentary sources (e.g. marbles from the I-V basement)? Compositional features of carbonates, involving major to trace elements, suggest mantle affinity. Carbonates from the Valmaggia intrusion were analyzed for carbon-oxygen isotope analysis together with samples from calcitic and dolomitic I-V marbles. Preliminary results exclude assimilation of C from sedimentary sources as isotopically heavy, sedimentary signatures discriminate the marbles from the isotopically light magmatic carbonates plotting within the mantle range and close to, but not within the Primary Igneous Carbonatite zone. This result is compatible with the markedly deep, mantle-related radiogenic and sulfur isotope signatures obtained for the I-V pipes by Fiorentini et al. (2018).

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DOI:10.19276/plinius.2018.03015

TRACKING THE SOURCES OF METASOMATIC MELTS IN THE FINERO MAFIC COMPLEX, IVREA-VERBANO ZONE

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A rare example where the inferred boundary between Earth's lower continental crust and upper mantle outcrops at the surface is the Ivrea-Verbano Zone (IVZ) of the Sothern Alps. The northernmost mafic suite of the IVZ is the Finero Complex, which hosts the Finero Peridotite massif which is unique amongst Ivrea peridotites for its high proportion of hydrous minerals (pargasite and phlogopite), whole rock isotopic signatures (Voshage H., Hunziker J.C., Hofman A.W., Zingg A., 1987) and enrichment in LILE and LREE (Zanetti A., Mazzuccheli M., Rivalenti G., Vannucci R., 1999). The Finero Complex is lens-shaped with the massif Phlogopite Peridotite (PP) at the core and is surrounded by the Amphibole Peridotite and two gabbroic units, the Layered Internal Zone between each peridotite and the External Gabbro (EG). Questions still remain on the timing and mechanism of emplacement of the peridotites into the surrounding lower crust and the metasomatic history of the entire Finero Complex. To address these ambiguities, we combine microstructural and petrographic relationships with a new suite of zircon isotopic and trace element data. New U-Pb crystallization ages, 201–323 Ma, from zircons collected from the EG, are similar to previously reported ages of the unit (Zanetti A., Mazzuccheli M., Sinigoi S., Giovanardi T., Peressini G., Fanning M., 2013), while our new ^{176}Hf/^{177}Hf$_{(i)}$ values range from 0.282659–0.282671. The youngest zircons of this group show the largest range in Hf isotopic values, ~6 εHf units, similar to those documented in high-temperature shear zones in the EG (Langone A., Zanetti A., Daczko N., Piazolo S., Tieplo M., Mazzucchelli M. , 2017). Zircons sampled from cross-cutting alkali dikes in the PP show U-Pb ages ranging from 175–220 Ma and ^{176}Hf/^{177}Hf$_{(i)}$ values ranging from 0.282660–0.282966 (~10 εHf). These data are markedly different from those of zircons recovered from chromitite layers within the PP, which exhibit negative εHf values consistent with a higher proportion of a crustal sourced component. We interpret that the chromitites crystallized during melt-rock interaction between the host peridotite and melts derived from partial melting of a metasomatised ancient fore-arc mantle wedge. The partial melting overlaps the timing of Variscan orogenic collapse and subsequent extensional rifting that led to an opening of an ocean basin in the late Jurassic. This new zircon isotopic and trace element dataset indicates no less than two types of melt-rock interactions have occurred within the Finero Complex, elucidates how melts are transferred from the mantle to the crust within an extensional tectonic setting and additionally explores the complex geochemical interactions taking place along melt migration pathways.

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EVIDENCE OF METASOMATIC PROCESSES IN THE LITHOSPHERIC MANTLE BELOW THE CAMEROON VOLCANIC LINE

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Spinel-bearing xenoliths recovered from alkaline basalt flows along the Cameroon Volcanic Line (CVL) have been examined to constrain metasomatic processes in the sub-continental lithospheric mantle. Investigated xenoliths from the mount Cameroon region, Oku massif, Adamawa and Kapsiki plateau on a distance of 1000 km include lherzolites, harzburgites and pyroxenites. The xenoliths exhibit well-equilibrated protogranular to porphyroclastic textures and no hydrous minerals. Equilibration temperatures were calculated using a range of thermometers in order to explore the thermal history of the CVL mantle. Two-pyroxene thermometry based on major element exchange yields a broad range of temperatures (840-1150 °C), assuming a pressure of 15 Kbar, broadly consistent with the spinel stability field. Temperatures estimated from Ca (9501040°C), Al (890-1130°C) and Cr (940-1140°C) thermometers in olivine show a slightly smaller range and a good correlation between the three methods. These temperatures are high compared to other spinel peridotites, indicating a reheating of the mantle prior to eruption. Calculated temperatures based on REE partitioning between Cpx and Opx provide a range from 1000-1260°C and are generally higher than the temperatures determined from trace elements in olivine. The water contents of olivines and pyroxenes were determined by FTIR spectroscopy using unpolarised light on unoriented crystals. Olivine typically contains <1 ppm H_2O. Opx and Cpx have water contents of 18-47 ppm and 39-145 ppm at their cores respectively, consistent with equilibrium partitioning. Some grains show a decrease in water content from core to rim, interpreted as diffusion related loss of H during ascent in the host magma. Lower water contents in olivine suggest more efficient diffusional loss in olivine than pyroxene. Our new data indicate that the xenoliths came from the lithospheric mantle situated just below a thinned crust of variable thickness, which explains the varied water contents and the large temperature range. Given the significant differences in closure temperatures of the different thermometers and the similarity in the calculated temperatures, our data implies a well-equilibrated and rapidly cooled upper mantle beneath the CVL. Further work will exploit this rapid cooling and well-equilibrated chemistry to inform on the relationships between melt production in the mantle, metasomatism and crustal evolution in the specific tectonic setting of the CVL.

DOI:10.19276/plinius.2018.03015 PLINIUS n. 44, 2018

SMALL-SCALE COMPOSITIONAL HETEROGENEITIES WHITHIN THE LITHOSPHERIC MANTLE UNDERNEATH COMALLO N. PATAGONIA, ARGENTINA

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The Patagonian Lithosphere represents the southernmost part of the South American Plate. It has been shaped by the ongoing subduction of the Nazca and Antarctic oceanic plates responsible for the formation of the Andean continental arc and the back arc region. The back-arc region is characterized by voluminous, late Miocene “main plateau” tholeiitic basalts and less-voluminous Pliocene “post plateau” alkali basalts. The latter frequently carry mantle xenoliths up to 30 cm in diameter.

The xenoliths in the “post plateau” alkali basalts closest to the Andean arc SE of the village Comallo in N. Patagonia are mainly foliated spinel harzburgites frequently with disseminate amphiboles and/or cm thick veins. One xenolith, a fine-grained amphibole-free spinel harzburgite, shows unique features. In a 2.5 cm long profile along the foliation the Fo content of the individual olivine grains decreases from 91.5 to 79.5, whereas NiO remains constant at c.0.40 wt%. The opx and cpx follow the same trend with Mg# ranging from 92.2 to 83.0 and 93.5 to 86.2 respectively. Furthermore, the Cr# of spinel ranges from 63.4 to 32.5 following the same trend as the pyroxenes. The cpx have concave downward LREE patterns indicating intergranular melt percolation and fractionation with increasing $(La/Sm)_N$ along the foliation from 1.5 in the grains with low Mg# to 4.1 in the high Mg# grains.

Based on the assumption of local equilibrium, the Fe-Mg partitioning between opx and cpx (opx-cpx geothermometer) would yield a dramatic temperature increase from 760°C in the high Mg# pairs to 1000°C in the low Mg# pairs over a distance of 2.5 cm. Such a temperature gradient is unfeasible and the observed Fe-Mg partitioning rather indicates grain-scale disequilibrium due to different rates of Fe-Mg exchange of opx and cpx during the metasomatic event.

The extreme compositional gradient in a mantle xenolith that otherwise exhibits a well equilibrated microstructure indicates interaction with a metasomatic agent not related to the host basalt. The most likely metasomatic agent is a melt e.g. from an upwelling vein. Emanating from the vein, the melt percolated into the wall rock preferably along the foliation leading to the most intense metasomatism closest to the melt source (low Mg#). The metasomatic front is well defined by the highest Mg#, whereas the contact to the melt source is not preserved. This gives us a handle on the life-time of this geochemical perturbation via inverse diffusion modeling.

CENOZOIC VOLCANISM IN LOWER SILESIA - NEW DATA ON BASALTIC FLOWS IN GRABISZYCE QUARRY NEAR LEŚNA (SW POLAND).

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Oligocene basalts at Grabiszyce quarry near Leśna in Poland (Sudetes, NE Bohemian Massif) are located within the Cenozoic Central European Volcanic Province. The Grabiszyce basalts are part of an extensive, partly eroded sequence of lava flows, one of the biggest in the Lower Silesia region. The volcanic succession at Grabiszyce is over 40m thick and consists of two lava flows with associated volcaniclastic deposits, separated by siliciclastic sedimentary rocks. (e.g. Śliwa, 1967; Birkenmajer et al., 2011, and references therein). Detailed volcanological or petrological studies have not been carried at Grabiszyce so far. The lower lava flow is ca. 20 m thick, significantly thicker than the upper one, and presents well developed columnar joints. The lower flow contains significant amounts of peridotite xenoliths up to 5cm in size (Puziewicz et al., 2015). Microscopic observations show the abundance of euhedral to subhedral phenocrysts of olivine, pyroxene and small amounts of amphibole and nepheline. The phenocrysts of pyroxene reveal zoning, often with hourglass texture. The groundmass is microcrystalline and contains olivine, pyroxene (augite, diopside), plagioclase and opaque minerals (ilmenite, chromite). Using the TAS diagram the rock was classified as a basanite. High bulk-rock MgO and Ni (c. 11% and 360 pmm) indicate rather primitive composition. The presence of nepheline is a sign of silica undersaturated bulk-rock composition. The presence of xenoliths suggest rapid magma ascent from the mantle, whereas zonation of phenocrysts suggests disequilibrium crystallization *en route* to the surface, and/or in a sub-volcanic magma chamber. In contrast, the upper lava flow is much thinner, up to c. 5 m, does not contain peridotite enclaves but bedrock xenoliths of silica-rich rocks occur. Also, the lavas are almost aphyric and consist mainly of a fine-grained groundmass composed of plagioclase, olivine, biotite, Fe-Ti oxides – magnetite and ilmenite. Subparallel alignment of plagioclase laths defines the trachytic texture. Rare phenocrysts are represented by zoned augite. There are also euhedral amphibole phenocrysts (pargasite) partly replaced by augite and magnetite (possibly due to decompression and volatile loss upon the eruption). Using the bulk rock composition the rock was classified as a basaltic trachyandesite. Relatively high silica, low MgO and Ni (c. 3.2% and <20 pm) indicate rather evolved composition. This, together with distinctive petrographic features and different set of xenoliths (of crustal, not mantle origin) compared to the lower flow, are likely signs of a longer and more advanced differentiation at a sub-volcanic level. Both the basanite and the basaltic trachyandesite from Grabiszyce represent the sodic alkaline series, and their trace element patterns, resembling the OIBs, are rather typical of Cenozoic within-plate mafic lavas found in adjacent areas. Parental magmas of both lava flows probably originated from similar mantle source, but underwent different evolution. The basanite magma erupted after limited differentiation and crystallization within the magmatic system. The trachyandesite magma was emplaced after more prolonged differentiation, probably due to fractional crystallization as well as contamination by crustal rocks. Further studies, including mineral thermobarometry and the determination of Crystal Size Distribution patterns are planned to recognize the magmatic processes in more detail and constrain a model of the magmatic system. This work is partially funded by AGH research grant No 11.11.140.319.

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A DIFFUSION-CONTROLLED TRACE-ELEMENT DISEQUILIBRIUM MODEL FOR TWO-PHASE REACTIVE TRANSPORT IN MAFIC-ULTRAMAFIC SYSTEMS

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We extend the capabilities of our multi-phase multi-component reactive transport (MPMCRT) approach (Oliveira *et al.,* 2018) for diffusion-controlled disequilibrium trace-element transport in the Earth's mantle. Trace-element transport is considered through a porous medium composed of two dynamic phases (fluid and solid), six thermodynamic phases (olivine, clinopyroxene, orthopyroxene, garnet, spinel and plagioclase) and seven basic components (SiO_2, Al_2O_3, FeO, MgO, CaO, Na_2O, Cr_2O_3). The model incorporates experimental data on mineral/fluid partition coefficients for rare-earth elements (REE) and pressure- and temperature-dependent diffusivities. Unlike most previous approaches of trace-element disequilibrium transport (*e.g.* Bodinier *et al.*, 1990, Vernières *et al.*, 1997), we take advantage of a sound thermodynamic model in order to consistently retrieve the mineral assemblages, volume fractions of fluid and solid, melting rates of mineral grains (i.e. thermodynamic phases) and other physical properties (*e.g.* density, heat capacity). For that purpose, we use components of the software PerpleX (Connolly, 2009) to perform dynamic Gibbs free-energy minimization based on the internally-consistent database of Jennings and Holland (2015), together with a new computational approach allowing for local thermodynamic disequilibrium. This enables a thermodynamically consistent coupling of the governing set of mass, momentum, energy and chemical mass balance equations, for both major and trace elements. Simple decompression-melting experiments demonstrate that this approach successfully captures melt generation, migration and melt-rock interactions (*e.g.* chromatographic reequilibration). Preliminary results emphasize the role of disequilibrium arising from diffusional reequilibration between thermodynamic phases and melt, especially during incipient melting. By tracking the compositions of fluid and solid domains along their P-T-t paths, we are able to provide new insights into the evolution of REE patterns during mantle melting processes. This has implications for the current use of trace elements in constraining the petrogenesis of mantle-derived magmas and the nature of their source regions, and consequently, for the understanding of the Earth's mantle evolution.

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PHASE RELATIONS, MELTING TEMPERATURES AND PETROGENESIS OF SOME CR-DIOPSIDE WEBSTERITE SEGREGATIONS IN MANTLE PERIDOTITE

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The hypothesis that melting of olivine-free lithologies in the mantle, generically labelled "pyroxenites", may contribute to basalt petrogenesis is testable only insofar as the chemical composition of the pyroxenite is specified. Mantle peridotites exposed at the Earth's surface ubiquitously contain "segregations" (a petrogenetically neutral term for layers, veins, dikes, lenses, etc.) of pyroxene-rich lithologies, which together cover a large enough range of chemical compositions to meet the needs of any geochemically inspired model. However, field relations show that most of these pyroxenite types were emplaced after their host peridotites were depleted by melt extraction. Exceptions are the Cr-diopside websterites (CDWs), which occur in fertile bodies (e.g., Ronda, Balmuccia) as the earliest pyroxenite segregations. Harzburgites (e.g., Massif du Sud, New Caledonia) have bronzitites instead. CDW segregations cross-cutting the peridotite fabric are generally ol-free, but the segregations show all stages of being tectonically rehomogenised into the peridotite, contributing to the fabric (modal layering). The cross-cutting CDWs consist of cpx+opx±sp±sulfide, with pyroxenes similar to the host peridotites in their high mg# (> 0.89) and cr#, and similarly but not identically depleted in incompatible-element (Na, Ti, REE, etc). These observations together with phase-equilibrium constraints, particularly the expansion of the primary phase volume of ol with decreasing pressure, suggest that CDWs are derived locally from their host peridotites, probably as upwelling ceases and the rate of macroscopic melt extraction goes to zero. So-called melt extraction trends (plots of CaO, Al_2O_3, etc vs. MgO) in some peridotite suites may instead represent different degrees of pyroxene depletion and re-enrichment caused by this process. Balmuccia is an example. The phase relations of a sp-free CDW from Ronda and two sp-CDWs from Balmuccia (one with a conspicuous amount of sulfide) have been experimentally determined at 1 atm., and 10, 15 and 20 kb. All three CDWs had sharp boundaries with their host peridotite, a granular texture with ~0.5 cm pyroxenes, and cpx:opx approximately 3:1, with no olivine. In all three the opx was resorbed into cpx below their solidi. These solidi were up to 100ºC above the anhydrous peridotite solidus, consistent with the peritectic melt reaction cpx+opx±sp = ol+melt, and the absence of opx. This shows that CDWs do not enhance melt productivity.

GEOCHEMICAL, MICROSTRUCTURAL AND TECTONIC EVIDENCE FOR GEODYNAMIC PROCESSES DURING HEROIC COLLISION EVENTS

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Large peridotite massifs scattered along the 1500km length of the Yarlung–Zangbo Suture Zone (southern Tibet, China), the major suture between Asia and Greater India, provide a natural laboratory to track multiple lithosphere evolution events throughout the complex history of this major collisional tectonic terrane. The massifs reveal: a sequence of repetitive docking of distinct lithospheric mantle domains over at least 350 My; repeated metasomatic and magmatic episodes that can be distinguished with detailed geochronology; mineral phases that indicate metamorphism under the conditions of the Mantle Transition Zone (MTZ); others that require a super-reducing environment over a range of depths (Griffin et al., 2016). Microstructural analysis of chromites with fine-grained inclusions of olivine (inverted wadsleyite), diopside and silica provide the first evidence for deformation by dislocation creep in the MTZ, an important consideration for interpreting seismic signals (Satsukawa et al., 2015). Re-Os-isotope data suggest that the subducted mantle consisted of previously depleted subcontinental lithosphere, dragged down by a younger subducting oceanic slab. Thermomechanical modeling shows that roll-back of a (much later) large-scale subducting slab would produce a high-velocity channelized upwelling that could exhume the buoyant harzburgites (and their chromitites) from the Transition Zone in <10 Myr. This rapid upwelling, which may explain some characteristics of the diamonds in the peridotites and chromitites, appears to have brought some massifs to the surface in forearc or back-arc basins, where they provided a basement for oceanic crust. This model can reconcile many apparently contradictory petrological and geological datasets. It also defines an important, previously unrecognized geodynamic process that may have operated along other large suture zones such as the Urals. These nano- to micro-scale to global observations using geochronology, geochemistry, mineral microstructures and geodynamic modelling are starting to fill in the huge 4D sudoku that is the complex evolution and deep architecture of such large-scale (heroic) collision events. This may allow us to identify analogous ancient events lurking in the geological record.

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MODES OF ASTHENOSPHERE-LITHOSPHERE INTERACTION REVEALED FROM EVOLUTION OF THE INTERNAL THERMAL STRUCTURE OF OROGENIC PERIDOTITE COMPLEXES

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The lithosphere-asthenosphere boundary zone is the place where thermal, mechanical, and chemical interactions between the rigid elastic plates and the convecting interior of the earth takes place. The study of its dynamic behavior is fairly important to better understand the evolution of the solid Earth, but processes taking place in the boundary zone are still unclear. Peridotite complexes in orogenic zones emplaced in solid state are regarded mostly as subcontinental lithospheric mantle emplaced into the crust at solid state, but there are several lines of evidence for involvement of asthenospheric activities, such as localized heating during exhumation of the complex (Ozawa, 2004), large-scale melt-related processes localized in a part of the complex, such as reactive melt porous flow and recrystallization (Lenoir et al., 2001; Müntener and Piccardo, 2003), and localized geochemical signature of the asthenospheric origin in the complex (Bodinier et al. 1991). On the basis of these observations, various tectonic models have been proposed (Ozawa, 1997; Kaczmarek and Müntener, 2008; Garrido et al., 2011; Hidas et al., 2013). In order to better constrain processes related to asthenospheric activities and its interaction with the lithosphere, we need to investigate large and continuous exposure of peridotite complexes on the scale of 10-50 km for clarification of temporal change of thermal structure before and during the asthenosphere-lithosphere interaction, and during their exhumation. Our recent studies on several orogenic peridotite complexes following this approach suggest two modes of asthenospheric thermal perturbation with distinct depth of occurrence. The first mode is documented in the Horoman peridotite complex, where the deeper lithospheric section underwent heating, but the shallower section did not (Ozawa, 2004). The other mode features thermal perturbation record only in the shallower lithosphere, but none in the lithosphere situated at deeper levels. We examined the Ronda complex, which shows a spatial distribution of pressure-sensitive peridotite lithology from the garnet to plagioclase facies, to clarify differential decompression path. We argue that operation of the second mode of asthenospheric thermal perturbation is recorded in the Ronda complex. The contrasted modes of thermal perturbation may imply different mechanisms of lithosphere-asthenosphere thermo-chemical and mechanical interaction, such as active upwelling vs. passive upwelling.

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LOW WATER CONTENT IN UPPER MANTLE XENOLITHS FROM THE NÓGRÁD-GÖMÖR VOLCANICC FIELD (NORTHERN PANNONIAN BASIN): GEODYNAMIC IMPLICATIONS AND THE ROLE OF POST-ERUPTIVE WATER LOSS

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The structural hydroxyl content of the lithospheric mantle is crucial as it is thought to play a key role in influencing several key physical properties (e.g. melting temperature, rheological properties). Furthermore, since hydrogen is considered as a highly incompatible element, the structural hydroxyl content of mantle xenoliths can be associated with metasomatic processes as well. Thus, it is important to characterize the distribution of structural hydroxyl in the lithosphere. In this study we analyzed 63 petrographically and geochemically well-defined upper mantle xenoliths from the Nógrád-Gömör Volcanic Field (Northern Pannonian Basin) using Fourier-transform infrared (FTIR) spectroscopy. The xenoliths show extremely low average structural hydroxyl contents (~0; 31 and 185 ppm for olivine, orthopyroxene and clinopyroxene, respectively) compared with regionally and worldwide reported values. The studied xenoliths reveal anomalous FTIR spectra characteristics and high clinopyroxene/orthopyroxenes structural hydroxyl ratios (average of ~8). Furthermore, there is no evident correlation between the structural hydroxyl content and other measured physical or chemical properties of the xenoliths. All these unique FTIR characteristics suggest that the Nógrád-Gömör xenoliths were affected by extensive re-equilibration, which may be linked to both pre- and post-eruptive processes. Extension-related pre-eruptive processes, including re-equilibration during extension induced lower hydrogen activity, are most likely to play the key role. However, a pre-eruption mantle metasomatism caused by an agent with low water activity cannot be excluded. Post-eruption cooling may also be significant, as suggested by the higher structural hydroxyl content in olivines from xenoliths hosted in more rapidly cooled volcanic pyroclastic facies. The novelty of our study includes new aspects on how structural hydroxyl may behave in young extensional basins, as well as providing some diagnostic features to indicate that re-equilibration under lower water activity may have occurred. This also contributes to distinguishing the structural hydroxyl loss linked to the pre-eruptive or the post-eruptive periods.

This project has been implemented with the support provided to I. J. K. from the National Research, Development and Innovation Fund of Hungary, financed under the K119740 funding scheme.

ALUMINUM DISTRIBUTION IN THE LOWER MANTLE: ab-initio GEOCHEMICAL MODELLING

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Aluminium is the sixth most abundant element in the Earth and it is a purely refractory lithophile element.

It is notably one of the main constitutes of melts generated from upper mantle melting : Al2O3 = 9-21 wt% is the range for the entire spectrum of mantle derived primary melts. Their crystallization on subsequent segregation, rise and cooling form the Crust over the Earth's history. The most intriguing aspect is that such Al reservoir partially or entirely turned on the mantle, through subduction, and that such process may involve mantle portions well below the magma source regions. Geochemical models aimed at explaining the elemental and isotopic evolution of the silicate Earth depict the scenario of the Earth's mantle as an open system, that continuously exchange matter with a chemically discrete reservoir. Among the major elements, aluminum is good proxy to evaluate if storing recycled materials may really influence the effective Earth's lower mantle composition.

Al may reside in Fe-periclase and Mg-Fe-perovskite/ bridgmanite or form a separate Al-rich phase (Pamato et al., 2015).

The baseline of the present work was to evaluate the bulk lower mantle aluminum contents modelling the potential aluminum entering in the bridgmanite *versus* a discrete Al_2O_3-phase, with Fe-periclase to compete the partitioning process.

Quantum modelling has an important say in enabling to reliably estimate the maximum Al uptake capacity of perovskite and to contribute to shed light on Al-incorporation mechanisms, thus contributing to open a *vista* upon the mentioned highly impacting geochemical implications.

Following the procedure of Merli et al. (2017), calculations are processed for pressures in the range of 24-80 GPa following the geochemical model and geotherm of Merli et al.(2016). The results indicate that bridgmanite becomes more and more relevant as an aluminium host with respect to Al_2O_3-phase (corundum) upon increasing pressure. However, the maximum Al uptake capacity of bridgmanite tends to decrease trailing down into the Earth's depth, though it is partly balance by a monotonic augment of Al-bearing perovskite amount. The combination of such effects leads to a global capacity of aluminium storage that is quasi-constant up to 50-60 GPa, and then it decreases, in favour of the competing phases, which are supposedly able to take alumina in terms of an energetic processes that are comparable with that of bridgmanite.

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MULTISTAGE METAMORPHIC EVOLUTION OF THE LOWER PARTS OF OCEANIC LITHOSPHERE IN THE HIGH-PRESSURE ZHELTAU TERRANE (WEST PART OF THE CENTRAL ASIAN OROGENIC BELT): INSIGHTS FROM PETROLOGICAL AND GEOCHEMICAL STUDIES.

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In the west part of the Central Asian Orogenic Belt (CAOB), representing the largest and long-lived contractional orogen in the world, Precambrian metamorphic formations normally comprise terranes, which are separated from each other by Early Paleozoic complexes of oceanic affinity (Degtyarev et al., 2017). HP and UHP rocks are normally found within the Precambrian terranes (e.g. UHP Zerendy Group in the Kokchetav terrane, the Aktyuz HP complex of the Chu-Kendyktas terrane); their formation is thought to have been related to the burial of various fragments of continental and oceanic lithosphere to HP conditions (e.g. Ernst et al., 2007). In the Zheltau terrane metamorphic formations are represented by Precambrian orthogneisses of the Anrakhai Complex and garnet-mica schists with relics of phengite, kyanite and Kfs of the Koyandy Complex (KC), containing bodies of eclogite, garnet pyroxenite, garnet amphibolite. The eclogites and garnet pyroxenites are interpreted to have been formed during subduction to HP conditions of mafic-ultramafic intrusions within continental crust (Pilitsyna et al., 2018). Within the KC pods of serpentinites with layers of Cr-spinel dunites and symplectite-bearing amphibolitized peridotites are also exposed among the garnet-kyanite schists. The peridotites contain Cpx-Opx-Spl symplectites together with Opx coronas around Ol, resulted from Grt – Ol reaction and garnet breakdown by itself at P ~ 11.5–14.5 kbar; T ~ 600–850° C, corresponding to the transition from garnet to spinel peridotites. Trace element distributions in the ultramafites indicate that their protoliths were probably Pl-bearing (shallow) magmatic cumulates, which were subducted to eclogite facies conditions and then exhumed along with the other HP complexes of the Zheltau terrane. Strongly depleted signatures of the ultramafites together with characteristic enrichment in LREE, Pb, Rb, Sr and negative Nb anomaly, indicate their derivation from melts sourced in depleted mantle within a suprasubduction (arc-basin) setting. The ultramafites do not represent fragments of mantle wedge, but represent metamorphosed crustal cumulates, which are clearly different from the well-known UHP garnet and spinel peridotites of the Kokchetav massif (Reverdatto et al., 2008). Besides, the Cr-Spl symplectite-bearing peridotites are the first to be described from the west CAOB. The study was funded by research projects № 14-27-00058 of the RSF and № 18-35-00199 of the RFBR.

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THE FIRST DATA ON THE MANTLE XENOLITHS OF THE DIAMONDIFEROUS KIMBERLITE PIPE LUELE (ANGOLA)

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The Luele kimberlite pipe (Angola) is the largest among the deposits discovered over the last 60 years. It is explored down to 400 meters. 26 xenoliths extracted from it's core were carefully analyzed. The samples can be divided into the following paragenetic groups (we use Whitney& Evans (2010) mineral abbreviations): garnet harzburgite (Ol+Grt+Opx); chromite wherlite (Ol+Cpx+Chr+Phl±Amp); spinel dunite (Ol+Spl±Phl); garnet lherzolite (Ol+Grt+Opx+Cpx+Phl±Amp) - this group combines granular and deformed lherzolites with identical mineral composition and chemical composition of rock-forming minerals; Ilmenite websterite (Opx+Cpx+Ilm+Phl±Grt±Amp); garnet clinopyroxenite (Cpx+Grt+Phl+Amp); eclogite (Cpx+Grt±Ilm±Phl±Amp); ilmenite dunite (Ol+Ilm±Phl); glimmerite (Phl); clinopyroxene glimmerite (Cpx+Phl±Amp±Usp). In addition to the listed minerals, in the xenoliths of various parageneses were found: rutile, Fe-Ni-Cu-sulfides, secondary magnetite of a wide range of compositions, calcium and strontium carbonates, apatite, barite, titanite, perovskite (Nb_2O_5 1.8-11 wt.%), pectolite, zircon, zirconolite (Nb_2O_5 up to 11 wt.%), crichtonite and exotic sulphides: shandite ($Pb_2Ni_3S_2$) and talcusite ($TlCuFe_{0.6}S_2$). The chemical composition of rock-forming minerals has some differences in comparison with similar minerals from the known diamondiferous pipes of Yakutia and South Africa. Garnets with a sharp and rare zoning are noted: 1) garnet of eclogite - chaotically spotted zoning of the whole grain in CaO-MgO-FeO (in wt.%: 4.8-8.6, 8.7-16, 14.8-21.5, correspondingly); 2) harzburgite garnet - strong heterogeneity of the edges with Al_2O_3-Cr_2O_3-FeO (in wt.%: 16.2-20.5, 2.4-9.9, 6.7-8.9, correspondingly). Olivine from chromite vherlites demonstrates strong spotted zoning (Mg# 86-92). Ilmenite from the olivine glimmerite has anomalously high TiO_2 (57.86 wt.%) and MgO (18.79 wt/%). Wherlite's chromite containing 54-63 wt.% of Cr_2O_3 practically does not detect in its composition Al_2O_3. A distinctive feature of the investigated xenoliths can be considered their strong enrichment with alkalis, hydroxyl group, titanium, to a slightly lesser extent - calcium, zirconium, REE, thallium. This implies non-traditional scenarios for the formation of rocks block in the given section of the lithosphere.

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EVOLUTION OF THE SIBERIAN PLATFORM LITHOSPHERIC MANTLE PERIDOTITE COMPOSITION AS A RESULT OF MULTIPLE CYCLES OF SILICATE METASOMATISM

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Xenogenic material of the cratonic lithospheric mantle (CLM) origin in kimberlites carries unique information about structure and composition of CLM at time of kimberlite emplacement. This material also carries information concerning the character and scale of the processes of the CLM structure and composition evolution occurring in time before the kimberlite emplacement. Of special interest are relatively rare finds of the CLM peridotite xenoliths with signs of multiple events of treatment in the mantle P-T conditions by different types of metasomatic agents of sublithospheric origin. This report presents results of mineralogical and geochemical study of several types of CLM peridotite xenoliths with clear sings of metasomatic treatment: 1) initially extremely depleted peridotites (megacrystalline Cr-pyrope harzburgites and dunites) with sings of initial treatment by carbonatite type of melts and then by basanite melts (presense of zoned rims with increase of Fe, Ca, Ti, Zr, Sr, Y and decrease of Mg, Cr, Ni on homogeneous core with S-type signature of REE distribution; appearance of newly-formed phases like Fe-enriched olivine of second generation, ilmenite and Cr-diopside prohibited in initial rock); 2) megacrystalline peridotites of wide range of scale of treatment by carbonatite melts: from insignificant related with processes of U-type CLM diamond formation to very intensive producing wehrlitization of initial harzburgite-dunite (presence of high-Cr, high-Ca garnets with minor amounts of Cr-diopside); 3) secondary enriched peridotites with composition range between depleted lherzolite and olivine bearing garnet pyroxenite. Of special interest are extremely fresh xenoliths of sheared Cr-pyrope lherzolits of Udachnaya pipe, Yakutia representing zone of lithosphere-asthenosphere interaction. A combination of compositional, geochemical, isotopic and petrographic features shows that these rocks were intensely deformed in the base of lithosphere, and have a complex evolution of their chemical composition, including a stage of partial melting and at least two stages of metasomatic enrichment.

This study was supported by RFBR Grant # 16-05-00811.

DOI:10.19276/plinius.2018.03015

THE ORIGIN OF ALPINE-HIMALAYAN OROGENIC K-RICH LAVAS: AN INTEGRATED EXPERIMENTAL AND GEOCHEMICAL APPROACH

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K-rich mantle-derived magmatism occurring within Alpine-Himalayan orogenic belt (AHOB) is characterized by the close association of different petrological members including high-K calk-alkaline, shoshonitic and lamproitic lavas. Rather than homogeneous peridotite, their source is heterogeneously metasomatised with the metasomatic assemblages – metasomes - situated in the veins within peridotitic wall-rock, originated through the melt-mantle interaction at the plate boundaries during the previous subduction.

In our 2GPa experiments, we simulate the melting processes within the mantle source of AHOB magmas aiming to resolve the perplexing issue of mutual occurrence of different K-rich lavas. We combine phlogopite-clinopyroxenites with either harzburgite or lherzolite in which these rock types make up two halves each capsule, allowing metasome-melt to infiltrate and react with the peridotite simulating melt:rock reaction. There are several general observations relevant to the origin of AHOB magmatism:

1. Two distinctive melt compositions are produced: the metasome-melt has lower SiO_2, higher MgO and similar K_2O contents compared with the infiltration-melt within peridotitic part, due to the assimilation of Opx and Ol crystallization that increases the Ol/Opx ratio. Compositional differences cause different densities and viscosities of two melts, with the metasome-derived one being more buoyant (lower SiO_2) then the infiltration one.

2. The infiltration melt from harzburgite compositionally resembles lamproites with high K_2O (9 wt.%), high K_2O/Na_2O >>2, with relatively low Al_2O_3 (<10 wt.%). The spinel with Cr# 83 and olivine with Mg# 93 also resemble AHOB lamproites.

3. When lherzolite is involved, the resulting infiltration-melts are silica-rich (up to 55 wt.% SiO_2), with high Al_2O_3 (up to 17 wt.%) and with the lower K_2O/Na_2O ~1, resembling AHOB high-K calk-alkaline and shoshonitic lavas.

4. Trace element content of infiltrating melt is fully controlled by the composition of the metasome, no matter if the peridotite is lherzolitic or harzburgitic.

These experiments allow clarification of the role of the mantle fertility on the composition of diverse K-rich melts. They also illustrate that melting of mixed source regions is not simply a question of producing and mixing two melt types; rather, the melt produced in the rock with the lower melting temperature react with the second rock, changing its mineralogy and taking up some of its components.

DOI:10.19276/plinius.2018.03015

ZIRCON CORONAS IN CRETACEOUS SUPRASUBDUCTION OPHIOLITIC CHROMITITE BODIES FROM EASTERN CUBA. AN EVIDENCE FOR AN EARLIER SUBCONTINENTAL MANTLE POSITION?

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Zircon coronas around Fe-Ti oxides are common in Fe-Ti ores and in mafic igneous and granulite facies rocks. Here, we report for the first time this type of texture in ophiolitic mantle chromitite bodies. The textures occur in samples from the contact zone between amphibole-bearing norites intruding the chromitite bodies located in the Moho Transition Zone of the Cretaceous Moa-Baracoa suprasubduction zone ophiolite, eastern Cuba. The mineralogy of the samples includes recrystallized Fe and Ti-rich chromite, altered plagioclase, orthopyroxene, clinopyroxene, Ti-rich amphibole, Mg-rich ilmenite, F-rich apatite and Fe-Ni-Cu sulphides with minor platinum-group minerals (sperrylite and laurite), Zr-bearing phases (baddeleyite, zirconolite, srilankite), rutile and titanite. The complete mineral assemblage documents an important enrichment of HFSE during mantle metasomatism. Zircon grains (from few microns to 50 µm in size) are systematically located along grain boundaries of ilmenite (up to 1 cm) forming zircon coronas. Zircons typically show granular textures clustered at the oxide rims, but some crystals are elongated following the ilmenite boundary. In addition, ilmenite grains up to 10 µm in size are in textural equilibrium with granular zircon grains. Some zircons show inclusions (up to 2 µm in size) of Zr-bearing phases such as zirconolite. The chemical composition of the zircons is highly variable in terms of major (64.54-65.54 wt% ZrO_2 and 1.34-1.54 wt% HfO_2) and minor elements. Thus, they exhibit chondrite-normalized REE patterns that are characterized by a positive steep slope from La to Lu, similar to the large majority of reported igneous zircons. However, the enrichment observed in the LREE is an order of magnitude lower than in most oceanic crust zircons, and there is also a general depletion in U, Pb, and Y. The Ti contents suggest temperatures in the range 1003-1290ºC, but some analyses of nominally clean zircon reach Ti contents up to 5800 ppm that translate into extremely high apparent temperature. Zircon coronas around ilmenite in textural equilibrium with chromite formed due to metasomatic reactions in the mantle which caused enrichment in HFSE and F. This process is typical of subcontinental lithospheric mantle and has never been described in oceanic mantle. They hence, likely document a complex history of the Moa-Baracoa ophiolite involving, perhaps, old pre-Cretaceous events within a subcontinental lithospheric mantle.

PERMIAN PYROXENITE DYKES IN HARZBURGITE ASSOCIATED WITH CRETACEOUS ECLOGITES AT THE EASTERN AUSTRO-ALPINE MARGIN

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Websteritic and rare garnet orthopyroxenite and clinopyroxenite dykes crosscutting harzburgite occur in the hanging wall of a Cretaceous eclogitized continental fragment of the Upper Austroalpine Sieggraben structural complex in the Eastern Alps, Austria (Putiš et al., 2000, 2002). These dykes record pressure-temperature changes from the mantle, subduction channel and an accretionary wedge. A clinopyroxenite dyke, dated at 252±2.4 Ma on zircon by U-Pb SIMS shows $\varepsilon_{Hf}(t)$ values of ca. 8–15 (av. 11 from 18 spots) suggesting a depleted mantle source of the dyke. The evolution stages were determined from various solid-solution mineral breakdown and recrystallization textures. The breakdown phases were the relic porphyroclastic Cpx1 (10–13 mol.% Ca-Ts), Opx1, Spl1 and Mg-Hbl1. The Ti-spinel and ilmenite exsolutions in Cpx1, Opx1, Spl1 and Amp1(Mg-Hbl) indicate slow cooling of the dykes in the host harzburgite in Spl stability field (D1 mantle stage). The Spl replacement by Grt, formation of the Grt exsolutions and coronas in/around Cpx1, Opx1 and Amp1 document continuous cooling and/or pressure increase (D2 mantle stage). Formation of Cpx-Grt symplectites replacing the Cpx1 rims suggests an exaggerated cooling due to approaching of this harzburgite fragment a supra-subduction mantle wedge (D3 mantle stage). The newly-formed matrix assemblage of Prp-Grs-rich Grt or Cr-Spl, low-Al Cpx, low-Al Opx, Ol, Ky, Zo, Rt, Prg records a subduction channel compression (D4 burial stage). The Grt or Cr-Spl replacement by Spl-bearing symplectites (Ol–Spl, Opx–Spl, Prg–Spl) indicates a HT decompression (D5 exhumation stage). The MP/MT conditions were estimated for the dyke incorporation in the Cretaceous accretionary/orogenic wedge (D6 stage). Anticlockwise P/T path was thus reconstructed for the mantle evolution stages and subduction burial up to the pressure peak (D1 to D4 stages). The P/T path continued then by almost isothermal exhumation (D5 stage), and by the decompression and cooling during the mantle fragment emplacement in an accretionary wedge (D6 stage). The pseudosection calculation from a clinopyroxenite dyke yielded peak metamorphic conditions at ~825–850°C and 25–27kbar (D4 stage) consistent with the eclogite-facies metamorphism of this mantle fragment. The eclogite-facies metamorphism of a continental fragment Ordovician gabbro from the Sieggraben structural complex was dated on zircon by U-Pb SIMS at ca. 90 Ma. We relate this age to the HT exhumation (D5) stage.

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ARCHITECTURE OF MANTLE ROOTS OF EUROPEAN VARISCAN OROGEN

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Central and eastern parts of the Variscan orogen of Europe consist of two subduction-collision systems (Saxo-Thuringian, ST, and Rheno-Hercynian, RH, Zones) separated by a fossil volcanic arc (Mid-German Crystalline High, MGCH), and an extensive Moldanubian Zone located to the south (Franke et al. 2017, Lardeaux et al. 2014). Cenozoic alkaline volcanic rocks, related to rifting in the foreland of Alps, are spread over most of the Variscan areas and locally carry peridotitic samples of subcontinental lithospheric mantle (SCLM). These peridotites were the subject of numerous studies, which demonstrated that SCLM beneath European Variscan orogen is lithologically variable. It is therefore tempting to investigate if the roots of major tectonostratigraphic units of the orogen differ petrologically.

After the Cenozoic metasomatic overprint is filtered off, it appears that the eastern part of ST Zone ("Lugian" unit) is underlain by strongly (up to 35 %) depleted harzburgitic mantle of oceanic affinities, which possibly represents the slice of Rheic Ocean plate attached to the Bruno-Vistulian terrane. Mantle roots of central and western part of the ST Zone are heterogeneous. Locally, significant orthopyroxene was added to peridotites. This suggests reactive percolation of orthopyroxene-saturated melts in the strongly depleted mantle. The mantle underlying RH zone and MGCH seems to be similar to that of Western ST. The SCLM underlying ST, RH and MGCH parts of orogen supposedly consists of slices of continental and oceanic plates assembled during the Variscan orogeny, with possible remnants of mantle wedge.

The mantle underlying the West Moldanubian (sensu Lardeaux et al. 2014) unit possibly originated due to refertilization of depleted harzburgites (Lenoir et al. (2000) or asthenosphere upwelling and "lithospherization". The large-scale upwelling could have happened during orogen delamination (late Carboniferous-early Permian).

Our study shows that the SCLM beneath the Variscan orogen of Europe has two major architecture styles. The majority of orogen is underlain by mantle fragments assembled during collisional stage of orogen growth. The second major style is that originated during late-orogenic delamination and asthenosphere upwelling.

Funding: This study was possible thanks to the project NCN UMO-2014/15/B/ST10/00095 of Polish National Centre for Science to JP.

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ARCHAEAN OCEANIC CRUST AND VOLATILE RECYCLING: EVIDENCE PRESERVED IN THE SUBCRATONIC MANTLE

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Mantle eclogites represent the oldest relics of the primitive crust, preserved in the lowermost part of continental roots, accessible only as xenoliths sampled by kimberlite magmas. This study focuses on the petrology and geochemistry of 13 non-metasomatized eclogite xenoliths from the Kaapvaal and Siberian cratons. These samples derive from the base of the cratonic keels and include bimineralic, (garnet - omphacite) and corundum (cor-) bearing eclogites.

Reconstructed whole rock incompatible element compositions of bimineralic eclogites are consistent with an Archaean to Paleo-Proterozoic protolith derived from an evolved picritic liquid, whereas cor-bearing eclogites reflect a pyroxene-dominated cumulate. Together with the wide range in $\delta^{18}O$ values (1.1-6.6 ‰), these compositions adhere to a depleted oceanic crustal protolith, which underwent low-to high-temperature hydrothermal alteration.

The omphacite within these samples preserve a total water content roughly between 2750 and 5300 ppm and between 720 and 4900 ppm in eclogites from the Siberian and Kaapvaal cratons respectively. It is generally accepted water can be introduced into the mantle via a subducting slab, bearing hydrous minerals, however this is believed to be restricted to the shallow part of the mantle. Water preserved in nominally anhydrous minerals (NAMs) attest to water being preserved in the subcratonic mantle down to the Lithosphere-Asthenosphere Boundary, among which omphacite, a main constituent of mantle eclogites, have the highest water content.

Regardless of craton and eclogite emplacement, omphacites with highest water contents (> 4000 ppm) generally have low δD values (<-110 ‰) and samples with lower water contents have slightly higher δD values (-100 to -90 ‰), as a possible result of partial dehydration. Although dehydration effects on hydrogen isotope fractionation remain poorly understood at mantle conditions, two distinct trends towards present mantle composition (-90 to -60 ‰) are preserved, interpreted as evidence for slow re-equilibration with the surrounding mantle.

It is inferred oceanic crustal recycling in the Archaean may have played an important role on global water cycle and water incorporation in the upper mantle. Recent studies suggest Archaean mantle had lower oxygen isotope composition than modern mantle, which consequently may be the case for hydrogen and other volatile components.

EXTREME HF-DEPLETED ISOTOPIC COMPONENT IN SPINEL PYROXENITES FROM THE LIGURIAN MANTLE (ITALY)

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Pyroxenites are considered a key enriched component in the veined mantle source of oceanic magmatism. Although being a volumetrically minor lithology in the mantle, they can have a significant impact on MORB compositions, given their fertile chemical signature and low melting temperatures. Mantle lherzolites in the External Liguride ophiolites (Northern Apennines) contain cm-thick spinel pyroxenite layers that originated by deep infiltration of MORB-type melts (Borghini et al., 2016). In a previous study (Borghini et al, 2013), we showed that pyroxenite emplacement caused systematic chemical and Nd isotopic changes in the host peridotites, thus possibly creating the enriched component often invoked to account for the low end of $^{143}Nd/^{144}Nd$ variation in MORBs. Consistent with Nd isotopes, Lu-Hf isotopic investigations on pyroxenite-peridotite profiles show that peridotites adjacent to pyroxenite layers are shifted to low initial (160Ma) EpsilonHf values: they thus define, together with a few pyroxenites, an enriched Hf isotopic mantle component. Moreover, pyroxenites exhibit an overall significant EpsilonHf variation, covering both enriched and extremely depleted compositions (EpsilonHf values up to 26-28). Such Hf isotopic signatures are the consequence of very heterogeneous HREE and Lu/Hf ratios in pyroxenites (both cpx and whole-rock), likely inherited by primary garnet (absent in the present mineralogy). Our results corroborate the role of pyroxenite-peridotite interaction in creating the enriched mantle components often invoked to explain the isotopic variability of MORBs. Also, our study shows that pyroxenites preserving a garnet-bearing chemical signature can develop over time very depleted Hf isotopic compositions, thus constituting chemically fertile, but Hf-depleted isotopic mantle domains, capable to explain the very depleted Hf isotopic compositions observed in some MORBs.

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DOI:10.19276/plinius.2018.03015

MELT-ROCK REACTION AT THE OCEANIC MANTLE- CRUST TRANSITION: EVIDENCE FROM HIGHLY SIDEROPHILE AND CHALCOGEN ELEMENTS IN TROCTOLITES FROM THE JURASSIC ALPINE OPHIOLITES

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Reaction of migrating melts with lithospheric mantle and lower crust most likely shape the chemistry of erupted ocean ridge basalts. At the mantle-crust transition this process is typically related to formation of olivine-rich troctolites (ORT), whose petrogenesis is generally attributed to reaction between an olivine-rich matrix and a migrating MORB-like melt crystallizing plagioclase and minor clinopyroxene. The original olivine-rich matrix may be formed by previous melt-mantle reaction or by olivine crystallization from primitive magmas.

This study reports whole-rock highly siderophile (HSE: Os, Ir, Ru, Rh, Pt, Pd, Au and Re) and chalcogen (S, Se and Te) element compositions, and Re-Os isotopes of ORT included within lower crust sequences from Jurassic Alpine ophiolites. The chalcophile element data were examined to (i) detect crustal vs. mantle contributions and (ii) constrain the effect of melt-rock reaction on the HSE and other chalcophile elements.

The ORT have similar Primitive Mantle (PM)-normalized HSE-Te-Se-S patterns showing a gradual increase of normalized concentrations from Os to Au (similar to Mg-rich magmas), and nearly flat Au-Te-Se-S patterns. These rocks have the highest HSE, S, Se and Te contents among primitive lower crustal rocks, thereby implying that they might be an important repository for some HSE within the lower oceanic crust (e.g., Os, Ir). Initial γOs (160 Ma) range from +0.2 to +5.9 and overlap with data on MORB glasses and typical Phanerozoic mantle values. The γOs data extend to slightly suprachondritic values that are uncommon in Jurassic Alpine mantle peridotites. Thus, the ORT may have an entirely crustal origin, or melt-rock reaction overprinted and partially removed the original mantle inventory of Os isotopes in these rocks. The PM-like S-Se-Te ratios in some ORT could support the latter interpretation, as they require that the magmas that formed the ORT were originally sulfide-undersaturated and only reached saturation during the formation of ORT. Thus, the crust-mantle transition below ocean ridges acts as a reactive filter that may significantly change the ^{187}Os/^{188}Os, chalcophile and compatible element chemistry of ocean ridge basalts.

NOBLE GASES AND CO_2 IN FLUID INCLUSIONS FROM WILCZA GÓRA MANTLE XENOLITHS (EGER RIFT, SW POLAND)

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This work investigates a selection of mantle xenoliths from Wilcza Góra (SW Poland), integrating the petrography and geochemistry of the minerals with the chemical and isotope composition of fluid inclusions (FI). These xenoliths were brought to the surface by Miocene (20 Ma) intraplate alkaline basalts intensely erupted outside the northern part of the Eger Rift. Nodules are mostly harzburgites with rare occurrence of amphibole. Olivine (Ol) are classified in two groups based on the Forsterite content: 1) $Fo_{88.9-91.5}$, which account for fertile to residual mantle; 2) $Fo_{85.5-88.1}$, which testify for a large interaction with circulating (basic) melts. This dichotomy also regards orthopyroxene (Opx) and clinopyroxene (Cpx), which show two ranges of Mg# (87-90 and 91-93) and clear evidences of recrystallization. FI hosted in minerals are dominated by CO_2 with N_2 as second major species. The carbon isotope composition of CO_2 ($\delta^{13}C$ V-PDB) ranges between -4.7‰ and -3.1‰, mostly within the typical MORB range ($-8‰<\delta^{13}C<-4‰$), without any correlation with the CO_2 content, thus excluding any influence of magmatic degassing. The $^3He/^4He$ corrected for air contamination (Rc/Ra) is 5.9-6.2 Ra in Ol, 6.3-6.8 Ra in Opx, and 6.7-6.9 Ra in Cpx. These values are within the range proposed for European SCLM (6.1±0.9 Ra). The increase of $^3He/^4He$ from Ol to Cpx is decoupled from helium concentration. The geochemistry of FI shows systematic differences between Ol and Opx-Cpx in some key ratios (i.e., $He/^{40}Ar^*$, He/CO_2). These differences are not related to diffusive fractionation of helium from FI, because they occur at almost constant or even increasing $^3He/^4He$. Alternatively, the variations can be ascribed to variable extents of partial melting, overprinted by at least one metasomatic event, as also suggested by the petrographic and geochemical features of the minerals. Cpx, Opx, and amphibole have been added to the pristine harzburgite by carbonated hydrous silicate melt related to Cenozoic volcanism. This process allowed the entrapment of CO_2-rich inclusions resembling the chemical and isotope composition of the metasomatizing fluids. As a result, our data reflect a mixing in two terms: 1) the residuum mantle, resulting from partial melting of European SCLM; 2) the metasomatic agent, strongly He-depleted and characterized by a MORB-like $^3He/^4He$.

CHEMICAL AND ISOTOPIC EVOLUTION OF MANTLE PERIDOTITES DURING PLAGIOCLASE-FACIES MELT-ROCK INTERACTION (TUSCANY OPHIOLITES, ITALY)

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Here we present mineralogical, geochemical and Nd-Hf isotope data on mantle peridotites from the Monti Rognosi Jurassic ophiolite in southern Tuscany. The ophiolites are mainly composed of serpentinitized peridotites containing small gabbroic bodies. Relatively fresh mantle assemblages are locally preserved. Selected samples are clinopyroxene-poor lherzolites (Cpx ~5-7 vol %) with a porphyroclastic texture. Clinopyroxene porphyroclasts are generally corroded, most likely because of reaction with a melt that crystallized thin gabbroic (Pl + Opx) veins and patches. The clinopyroxene has relatively high Al_2O_3 (~7 wt. %), TiO_2 (0.5-0.8 wt. %) and Na_2O (0.2-0.5 wt. %). Accessory Cr-rich spinel with irregular shapes is present and rimmed by calcic plagioclase (An= 81-90 mol%). High Cr# values of the spinel (43-46) are associated with high TiO_2 contents (0.5-0.8 wt. %), as typically observed in plagioclase-bearing peridotites that experienced melt/rock reactions.

REE-in-two-pyroxene geothermometer based on trivalent REE+Y exchange between Cpx and Opx, yields high T values (TREE) of 1260-1380°C, significantly higher than Ca-in Opx (1090 ± 20 °C), in agreement with the high closure temperature for the REE-in-two-pyroxene geothermometer. The remarkably high TREE may reflect thermal disturbance and/or geochemical disequilibrium due to melt-rock reaction under plagioclase facies conditions. Clinopyroxenes show wide REE heterogeneity, ranging from markedly to slightly LREE-depleted (CeN/SmN = 0.02-0.40) with nearly flat and highly variable HREE (YbN = 10-22) and Lu/Hf ratios (0.22-0.90). Bulk rock REE compositions apparently record small degrees (2-4%) of fractional melting in the spinel stability field, whereas the clinopyroxenes do not match the computed REE compositions of any mantle residual clinopyroxene. The peridotites are therefore considered to not represent simple partial melting residues. We attribute the clinopyroxene compositional variations to reaction with Opx-saturated, MORB-type melts. Nd-Hf isotope compositions of bulk rocks and clinopyroxenes calculated at the time of the gabbro intrusion (εNd = +8.4 to +9.9, εHf = +9.1 to +13.5) mostly fall in the MORB field. Highly radiogenic Nd preserved by one clinopyroxene separate (εNd = +15.6) hint that the peridotites experienced an ancient depletion event and that the reactive melt infiltration reset both Sm-Nd and Lu-Hf isotope systems.

NEOGENE ULTRABASIC VOLCANIC ROCKS IN CENTRAL URUMIEH-DOHKTAR MAGMATIC ARC (NW IRAN): MELILITITES AND NEPHELINITES IN SUBDUCTION SETTING

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About 180 km SW Tehran (central-northern Iran) young (likely <1 Myr old) and small volume lava flows are emitted from volcanic chains close to Nowbaran town. These volcanoes belong to the so-called Urumieh-Dokthar Magmatic Arc (*UDMA*), running from NW to SE along the western margin of Iran. The volcanism of the *UDMA* is related to the NE-ward Neotethys Ocean subduction beneath the Iranian plate since Early Cretaceous time, evolved into Arabia-Iran continental collision during early Cenozoic. The lava flows consist of strongly ultrabasic magmas, represented by melilitites and nephelinites. Clinopyroxene is the most abundant microphenocryst, followed by olivine, calcite and biotite. Diopside is always twinned or shows normal zoning, and olivine is Mg-rich, with Fo content ~86. Primary calcite largely occurs as large plagues (often including opaque minerals and diopside); Mg-rich (Mg# ~0.87) and Ti-rich (TiO_2 up to ~7.3 wt%) phlogopite-eastonite is also frequent. Cancrinite-sodalite group minerals are the main groundmass foids, together with nepheline and minor Ti-magnetite. The investigated rocks show anomalous mineral paragenesis and whole-rock chemical compositions compared to the other Cenozoic volcanic rocks occurring in Iran. SiO_2 content is extremely low (down to 36.0 wt%), with CaO reaching contents as high as ~19.2 wt%, coupled with generally high MgO (~9.1-13.9 wt%). Alkalis range between ~2.2 and 6.2 wt%, with Na_2O/K_2O varying from ~0.9 to 8.5. Primitive mantle-normalized patterns show marked troughs at K, Rb and Pb and enrichment in Nb and Ta, resembling typical HIMU-OIB compositions. The presence of these compositions imply a carbonatitic component in the mantle source, which is uncommon in subduction-related settings, and certainly unique within the entire Cenozoic volcanic rocks of UDMA. Experimental petrology studies in the last decades have demonstrated that carbonated peridotite is able to produce melts characterized by extremely low content of silica but high amount of CaO and MgO (e.g. Presnall and Gudfinnsson, 2005; Hammouda and Keshav, 2015). It is therefore necessary to understand these peculiar rock compositions in order to constrain their mantle source, the role of carbonates and their origin in a subduction-related setting.

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MELTING AN ANCIENT, REFRACTORY MANTLE AT MID OCEAN RIDGES

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A growing number of geochemical investigations on peridotites suggest that the chemical heterogeneity of the Earth's mantle is more extreme than the magmas erupted on the surface. The finding of extreme Os, Nd and Hf isotope compositions in residual peridotites implies that anciently depleted domains locally exist in the upper mantle, preserved during the long term-advection and re-homogenization in the asthenosphere [Liu, C. et al., 2008; Stracke, A. et al., 2011]. A common view is that, owing to their refractory character, these depleted portions of the asthenosphere do not substantially contribute to the chemistry of the ocean floor basalts. However, we have no good understanding on the potential of such refractory domains in determining the isotopic signature of the oceanic basalts, as melts with extremely radiogenic Nd-Hf isotopic compositions have never been observed [Salters V. J. M. et al., 2011]. Here we present new data on two large replacive bodies found in a MOR-type mantle section exposed in the Jurassic Alpine ophiolites (Lanzo South Massif, Italy). Field and geochemical data indicate a formation by reaction between highly depleted melts and the host peridotites. The clinopyroxene from these replacive rocks are characterized by strong depletions in incompatible elements and have MORB-like Nd isotopic compositions but extreme radiogenic Hf-isotopic compositions (initial εHf up to 200). The simplest way of explaining the depleted trace elements in combination with the decoupled isotopic compositions is that the harzburgites were infiltrated by a melt with isotopic compositions inherited from an anciently (>1 Ga) depleted mantle. The existence of melts from refractory sectors of the asthenosphere allow us linking global correlations in the Nd-Hf isotopic space of MORB with an architecture of the sub-ridge mantle where such ancient, depleted component is a matrix in which more enriched domains occur as pockets.

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HIGHLY SIDEROPHILE AND CHALCOPHILE ELEMENT BEHAVIOUR IN ABYSSAL-TYPE AND SUPRA-SUBDUCTION ZONE MANTLE: CONSTRAINTS FROM THE NEW CALEDONIA OPHIOLITE

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The New Caledonia Ophiolite hosts one of the largest obducted mantle sections worldwide, offering a unique opportunity to investigate key mantle processes. The mantle section is dominated by a harzburgite-dunite sequence but it also includes minor spl and pl lherzolites. Geochemical data indicate that the harzburgites suffered multiple melting episodes followed by localized interaction with fluids in a supra-subduction zone setting, while the lherzolites are akin to abyssal-type peridotites (Secchiari et al., 2016).

In order to constrain how these processes affected the behaviour of highly siderophile (HSE: PGE=Os-Ir-Ru-Rh-Pt-Pd+Au-Re) and chalcophile elements (S-Se-Te), a set of fully characterised peridotites (major, trace element, Sr-Nd-Pb isotopes) has been studied.

The lherzolites are slightly serpentinized and display chondritic to slightly suprachondritic $^{187}Os/^{188}Os_i$ (0.1273-0.1329 at 53 Ma). The gently sloping HSE patterns with increasing depletion towards Au are similar to other oceanic or continental lherzolites. These features were inherited from sulphide melt-silicate partitioning during partial melting, melt infiltration and mixing of different generation of sulphides. S contents (202-1268 ppm) were likely increased by serpentinization, whereas Se/Te are similar to other lherzolites.

The harzburgites can be grouped in two sub-types. Type-A ($+9.3 \leq e_{Ndi} \leq +13.3$) have subchondritic $^{187}Os/^{188}Os_i$ (0.1203-0.1254), low Os (0.55-1.51 ppb) and very low Re/Os. Their HSE patterns display strong fractionations, enriched Os-Ir-Ru segments and Pt-Au positive spikes. S-Se-Te are often below the detection limit. These patterns can be ascribed to high melting degrees, leading to sulphide exhaustion and PGE alloys stabilization. Type-B harzburgites ($-0.8 \leq e_{Ndi} \leq +4.0$) show chondritic to suprachondritic measured $^{187}Os/^{188}Os$ (0.1273-0.1524), notably low Os-Ir contents (0.003-0.277 ppb) and highly variable $^{187}Re/^{188}Os$ (2-30). The "melt-like" HSE patterns exhibit strongly fractionated Os-Ir-Ru (Os_N/Ru_N=0.02-0.46), negative Pt anomalies and positive Au spikes. S-Se-Te are close to or below the detection limit. We interpret these compositions as reflecting localized modification of type-A harzburgites by subduction-related fluids and/or hydrous melts, leading to partial destabilization of Os-Ir rich alloys due to high f_{O2}.

Our work suggests that some of the features shown by arc lavas (e.g., positive Pt spikes) may mirror the geochemical signature of the sub-arc mantle.

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GEOCHEMICAL AND Sr-Nd-Pb ISOTOPE INVESTIGATION OF THE NEW CALEDONIA HARZBURGITE: UNRAVELLING THE EVOLUTION OF A SUB-ARC MANTLE SOURCE

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Exposures of arc-related mantle sections preserved in ophiolites constitute a natural laboratory for investigating subduction zone processes. The New Caledonia ophiolite consists primarily of harzburgites, locally overlain by mafic-ultramafic cumulates, and minor spinel and plagioclase lherzolites (Secchiari et al., 2016). Recent studies have shown that the harzburgites and the associated cumulates represent a crust-mantle transect formed in a nascent arc environment (Marchesi et al., 2009; Pirard et al., 2013; Secchiari et al., submitted). However, scarce geochemical data are available for the harzburgites, so that the processes recorded by this mantle section are still poorly constrained.

In order to unravel the evolution of the New Caledonia harzburgite, a comprehensive geochemical dataset (major and trace element, Sr-Nd-Pb isotopes) has been obtained on a new set of fresh samples unaffected by serpentinization.

The studied harzburgites are low-strain tectonites showing porphyroclastic textures, locally grading into promylonitic textures. They exhibit a refractory nature, as attested by the notable absence of primary clinopyroxene, very high Fo content of olivine (90.9-92.9 mol.%), high Mg# of orthopyroxene (89.8-94.2) and Cr# of spinel (39-71). Thin films of undeformed clinopyroxene with very low Na_2O (0.03-0.13 wt.%) and TiO_2 (0.04-0.10 wt.%) contents have been also recognized in association with Al_2O_3- (0.88-1.53 wt.%) and CaO- (0.37-0.97 wt.%) poor secondary orthopyroxene.

The harzbugites display U-shaped REE profiles (Gd_N/Yb_N=0.06-0.48) with remarkably low REE concentrations (< 0.1 chondritic values), in the range of modern subduction zone peridotites. Geochemical models shows that the HREE composition of the harzburgites can be reproduced with high degrees (up to ~25%) of fractional melting of a DMM source in the spinel stability field. Extended trace element diagrams highlights depleted compositions coupled with strong positive anomalies for Pb and FME (i.e. Cs, Ba, Sr).

Nd isotopic ratios range from poorly to slightly radiogenic ($-0.8 \leq \varepsilon_{Ndi} \leq +13.3$) and negatively correlate with Sr isotopes ($0.70257 \leq {}^{87}Sr/{}^{86}Sr \leq 0.70770$). Pb isotopes cover a wide range, trending from DMM toward enriched, sediment-like, compositions.

We interpret the geochemical signature displayed by the New Caledonia harzburgite as reflecting a highly depleted sub-arc mantle source variably modified by fluid input and/or hydrous melts percolation during Eocene subduction.

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AMPHIBOLE AS WINDOW ON THE ARCHEAN MANTLE COMPOSITION

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The Archean mantle is among the few reservoirs on Earth preserving records of the early differentiation of the planet. Because the Archean mantle is poorly preserved, only Archean komatiites and few other mantle-derived rocks are the only source of information on the Archean mantle composition we presently have (Sossi *et al.*, 2016). However, these rocks generally have strong metamorphic overprints that cause the bulk rock composition to be poorly representative of the original chemical signature, in particular for volatile elements and elements with high fluid mobility. Furthermore, olivine, orthopyroxene or clinopyroxene - the major constituents of these ultramafic rocks - are, all minerals that operate a significant filter in the uptake of trace elements; thus hindering precious information on the Archean mantle. Here we propose a novel approach in deciphering the Archean mantle geochemical signature based on the geochemical characterisation of amphibole, which is a mineral capable to incorporate a large number of petrologically relevant elements including volatiles (Tiepolo *et al.*, 2007; Giesting *et al.*, 2014). Several studies have shown the presence of primary hydro-magmatic amphiboles among accessory minerals of Archean ultramafic rocks (Stone *et al.*, 2003; Fiorentini *et al.*, 2012). We have selected amphibole-bearing samples from komatiites of the Agnew-Wiluna greenstone belt (Western Australia), from the tholeiitic and Fe-picritic suites of the Abitibi greenstone belt (Canada) and from the ferropicrites of the Pechenga Complex (Russia). Phanerozoic amphiboles from mafic and ultramafic rocks were also considered for comparison. We have characterised amphiboles for major-, trace- and volatile element contents. The δD and $\delta^{18}O$ isotopic composition of amphibole has been also determined by HR-SIMS. Results suggest plume-related origin for the selected Archean ultramafic rocks and point to a significant change in mantle source composition at the origin of Archean and Phanerozoic primary mantle melts. Moreover, elemental and isotopic results on volatiles reveal the occurrence of hydrous deep mantle sources in the Archean. Hence results have significant implications for the debated “wet or dry” signature of komatiites.

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DOI:10.19276/plinius.2018.03015

MINERAL CHEMISTRY OF ULTRABASIC ROCKS FROM AM-TIEN HILL, NUI NUA COMPLEX (NORTH VIETNAM) – PRELIMINARY RESULTS

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The Permian-Triassic ultrabasite samples from Nui Nua Complex (NNC) in Thanh Hoa Province, North Vietnam (Halpin et al., 2016) were subject of the preliminary mineralogical and chemical studies. The NNC is a part of the Song Ma suture zone (Hutchison, 1975; Findlay and Trinh, 1997; Chuong et al., 2001). This unit is surrounded by Triassic sedimentary formations in the S-SW and quaternary sediments in the N-NE parts. The olivines are the main components of the analytical rocks. The studied samples shows with near equal high forsterite contents ranged from 89,79 to 90,92% wt. and with NiO concentration between 0,36 to 0,52% wt. The determined MnO quantity is also in the narrow range of high values (0,08-0,18% wt.) and in selected samples the Zn and Co traces also have been determined. The serpentine minerals are Al-poor varieties (below 2% wt. of Al_2O_3) of lizardite which often exhibit as a fillings in cracks and fissures. Two analyzed samples were a fibers of clinochrysotile with Al_20_3 contents exceed 2% wt. In the all analyzed serpentines from NNC the slight Fe enrichment is also observed. It can be explained by possibility of partial weathering of these serpentines in the tropical conditions. The three main groups of these rocks are the high-Mg variety orthopyroxenes belongs to enstatite-subgroup ($En_{88,26-90,05}$) and clinopyroxenes subdivided into diopside-augite ($En_{67,38-71,45}$ $Di_{24,98-30,37}$, $Fs_{2,07-3,59}$) and diopside subgroups ($En_{46,51-54,10}$ $Di_{40,66-50,58}$, $Fs_{2,59-5,24}$). All of pyroxenes have variable Cr_2O_3 contents between 0,02-1,16% wt. and low concentrations of NiO ranged of 0,01-0,14% wt. Accessory Cr-bearing spinels in their central parts of opaque grains are characterized by Cr-Al bimodality, but in the outer zones the increasing of Fe is clearly visible. The spinels from cores can be classified as a Cr-Al ones with # Cr between 0,47 and 0,49, and stable #Mg values in the 0,56-0,58 range. The Fe-rich magnetites occurring in rims have a wide ranges of Fe contents (up to 65% wt. of FeO) which is connected with strong depletion in Cr and Al components. Summing up, we can conclude that obtained results indicate different provenance of pristine ultrabasics from NNC in North Vietnam. The stability of forsterite contents in olivines can confirm restite character of primary peridotites but in the other side, presence of different generations of pyroxenes can evidenced of cumulative provenance of these ultrabasic rocks (websterites or lherzolites?).

This work was financially supported by the AGH University of Science and Technology research grant number 11.11.140.158 (Krakow, Poland) and University of Wroclaw research grant number 0401/0156/17 (Wroclaw, Poland)

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COMPACTION POCKET: A MECHANISM TO EXPLAIN OCCURENCE OF ALKALINE ROCKES IN OROGENIC BELT

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This study is based on an integrated approach, which combines results from petrology, geophysic and modeling to explain origin of continental alkaline magmatism in the Turkish-Iranian plateau (TIP). Synthesis of the petrological and chemical characteristics of the alkaline magmatic activities of the TIP extending from 80 Ma to present shows that alkaline lavas can be classified ultrapotassic (UK), transitional potassic to sodic (TK) and sodic-high potassium (HK) and –low potassium (LK) lavas, derived from multi components bearing mantles. Our synthesis of the most recent seismic tomography images show the presence of a large set of low velocities elliptic bodies, called "Compaction Pockets", scattered from base of the upper mantle to the base of the lithosphere beneath the TIP. A model is developed showing that the low velocity of the compaction pockets result from the percolation and concentration of volatile-rich melt liberated from Mantle Transition Zone, into large pockets. We argue that these large pockets result from the interaction of volatile-rich melts with the surrounding mantle at a temperature ~100 °C lower than the usual sub-continental mantle adiabat. This eventually results in the precipitation of hydrated and carbonated mineral phases (~8- 6.5 GPa and < 4 GPa), and partial melting of metasomatized mantle (6.5- 4 GPa) in the critical depths. Melt extraction via dykes occurs when the top of the compaction pocket successively crosses these critical depths. The three groups of UK, sodic-–LK and HK lavas may be linked to these three melt extraction events, respectively. Chemical composition of TK melt may also result of mixing of UK and sodic melt or partial melting of metasomatized mantle at the lithosphere depth. As a result, the "Compaction Pocket" model represent a robust new concept to explain continental alkaline magmatism in the context of orogeny.

ORIGIN OF THE BALMUCCIA OROGENIC LHERZOLITE MASSIF AND ITS IMPLICATIONS FOR THE CAUSES OF CHEMICAL VARIABILITY IN EARTH'S UPPER MANTLE

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Adiabatic decompression melting of upper mantle rocks, the segregation of these melts, subsequent stabilisation as crust and their eventual return into the mantle can engender compositional heterogeneity. Since the 1960s, the chemistry of the mantle has become increasingly informed by the petrologic study of peridotite xenoliths and massifs. The latter have the advantage of revealing field relationships over the km-scale and placing them in the context of *in-situ* mantle processes. Here we present a geochemical and petrologic study of the Balmuccia orogenic lherzolite massif, NW Italy, with a view to critically examining the causes of compositional variability in the Earth's upper mantle and its relation to basalt genesis. The massif's dominant lithology, comprising 85% of the massif, is a clinopyroxene-poor (13%) lherzolite riddled with two types of pyroxenites; Cr-diopside segregations boudinaged and rotated *en-echelon* into the plane of the foliation, and later, cross-cutting Al-augite veins. The former are often bound by dunitic 'depletion zones', which, together with Sr, and Nd isotope compositions indistinguishable from those of peridotites, points to their local derivation. Two-pyroxene thermometry constrains equilibration temperatures to 850°C, 500°C cooler than adiabatic asthenosphere. Bimodal Cr-diopside bands, at temperatures near the peridotite solidus, reach a consolute point at which only clinopyroxene, compositionally identical to that in lherzolite, is stable (O'Neill, this volume). Chemical variability in the mantle is thought to reflect variable degrees of polybaric melt extraction from fertile asthenospheric mantle. Though popular, this view is untenable given that lithological variation from lherzolite to dunite occurs on the hand-sample scale. Here we present a model in which clino- and orthopyroxene are segregated from olivine by pressure-solution re-precipitation owing to their higher competence and lower solidi relative to Fo_{90} olivine. This modal re-distribution explains the 1) compositional and isotopic similarity of pyroxenes in lherzolites and Cr-diopsides, 2) the spatial association of Cr-diopside with depletion zones and 3) chemical characteristics of global massif peridotites. The latter observation implies that this process must function on a global scale, likely during decompression and the deviatoric stress experienced by upwelling mantle when passing from an adiabatic to conductive thermal regime.

DOI:10.19276/plinius.2018.03015

ORIGIN OF SUB-CHONDRITIC Os/Ir RATIOS IN OFF-CRATON PERIDOTITE XENOLITHS: A CASE STUDY FROM THE FRENCH MASSIF CENTRAL PERIDOTITE XENOLITHS.

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Alkali basalt-borne peridotite xenoliths tend to exhibit lower Os concentrations and Os/Ir ratios (<1) than mantle tectonites. This may reflect preferential loss of Os during (i) lava entrainment, (ii) low temperature weathering of base metal sulfides (BMS), their main host minerals, or (iii) BMS dissolution during percolation of S-undersaturated silicate melts (Lorand and Alard, 2001; Lorand et al., 2003). To test hypotheses 2 and 3, 27 peridotite xenoliths from the French Massif Central (FMC) were analysed for HSE-S-Se-Te and Re-Os isotope systematics. These xenoliths show evidences of percolation by S-saturated (groups A and B xenoliths) or by S-undersaturated (group C xenoliths) silicate melts/fluids, with BMS weathering in each group spanning 0-100% (Lorand et al., 2003). Groups A and B xenoliths show PUM-like HSE, S, Se and Te concentrations, similar to those of mantle lherzolite tectonites and mostly attributed to high BMS contents. In contrast, group C xenoliths, which are spatially and temporally associated with the "FMC plume" and the percolation of large volume of S-undersaturated silicate melts show lower than PUM HSE-S-Se concentrations associated with pronounced sub-chondritic Os/Ir and Re/Pd ratios, and very low BMS abundances. Interestingly, in Group C xenoliths, the Os/Ir ratios positively correlate with the Os concentrations but none of these two parameters vary with the extent of BMS weathering. Our results suggest that the percolation of large volume of S-undersaturated silicate melts, while dissolving BMS, results in low Os concentrations and sub-chondritic Os/Ir in mantle xenoliths, either because (i) Os is more soluble than Ir in silicate melts, (ii) Ir-rich phases (i.e. alloys) are preferentially stabilised in the peridotite xenoliths in response to the desulfurization or (iii) percolating melts that imparted their HSE signature onto the peridotite residue.

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HF-ND ISOTOPE SYSTEMATICS IN MANTLE XENOLITHS FROM SIBERIA AND MONGOLIA

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Peridotite xenoliths provide rare direct samples of Earth's lithospheric mantle. Chemical and isotope analyses of their constituent minerals can provide crucial information about the chemical evolution and formation age of their source regions, if the effects of partial melting, metasomatism, metamorphism or surface alteration can be disentangled. Here, we present high-precision Hf and Nd isotope data together with trace-element compositions on coexisting clinopyroxene-orthopyroxene (cpx-opx) pairs from well-characterised spinel peridotite samples of different fertility from five different locations in Siberia and Mongolia. The trace element compositions of cpx-opx(-ol) and reconstructed whole-rocks reveal variable degrees and styles of metasomatism. The extent of isotopic disequilibrium between cpx and opx varies between and within the sample suite(s), but can distinguish between, and possibly date the age of, various metasomatic and depletion events. Information about the timing of depletion events can be preserved in the Lu-Hf isotope system although the Sm-Nd system is entirely reset by metasomatism. External and internal isochrons together with mixing models allow constraining the evolution of the continental lithospheric mantle. Near-equilibrium of Nd and Hf isotope ratios between cpx and opx in some peridotites from the Siberian craton indicate high-T isotopic equilibration before eruption. Any age information about prior depletion or metasomatism is obliterated in this case. However, samples from SE Mongolia show consistent internal and external Lu-Hf isochrons, and provide novel constraints about ancient depletion events, in line with cpx Sm-Nd model ages for the mantle.

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FRACTAL CHARACTERISTICS OF TEXTURES OF MANTLE XENOLITHS

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In our previous work (Tabor et al., 2010; GSL Sp. Pub. 337, 195-211) we developed a method of quantitative measurement of textures in mantle xenoliths, using skeletonisation and digital quantification of thin-section images. This work has now been extended to cover mantle peridotites from a wider range of origins, including from additional basaltic volcanic fields (Hungary, Scotland), kimberlites (Siberia, South Africa) and ultramafic massifs worldwide, and ultramafic ureilitic meteorites. Although the dimensions of the grains are different (e.g. larger mean grain section areas for garnet peridotites from kimberlites), the grain size analyses of these new samples plot on the same trend of mean grain-section area vs standard deviation, established in our earlier work, indicating that textures in peridotite rocks are a result of similar generative mechanisms (comminution and/or grain growth). We have now shown that our method can be used as a basis to provide a characteristic description of the shapes of grain-section outlines seen in thin-sections. We have determined the perimeter (P) of each individual grain, and the corresponding area (A) of each grain, in terms of the number of pixels, and have converted these into metric dimensions using a calibration grid. Plots of log (P) vs log (A) yield information concerning the fundamental characteristic of the grain shapes, i.e. whether they are Euclidean or fractal. We have validated our method by using skeletons of recognised fractal and Euclidean images, and have established that the thin-section skeletons can be best described in fractal terms. Our method has been authenticated by comparison with the alternative “box-counting” method for assessing fractal characteristics. However, the origin of the fractal geometry is not entirely clear from work on two-dimensional images, since even Euclidean objects cut randomly tend towards showing fractal characteristics. We have therefore also investigated the three-dimensional shapes of individual grains in mantle xenoliths by using two approaches: (1) disaggregation of xenoliths by an electric discharge technique which leaves the original shape of the mineral grains intact, followed by SEM imaging and CT scanning of epoxy grain mounts; (2) by CT scanning of individual xenoliths and visualising the shapes of grains. Both methods show the complexity and involution of the constituent grains, which strongly suggest their fractal nature.

EVIDENCE OF Nb/Ta HETEROGENEITY IN THE EARTH'S MANTLE

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The imbalance between the chemical composition of the silicate Earth and that of chondrites has arisen several geochemical paradoxes, which are used to model planetary accretion and better understand how Earth formed and evolved through time. Some of the key constraints on early differentiation processes assume that our proto-Earth had a bulk homogeneous subchondritic composition in the elements niobium and tantalum (Münker et al., 2003), and that no secular variation in their relative abundance occurred since accretion. Here, we provide new evidence that mantle domains variably enriched in niobium/tantalum, even approaching the chondritic composition, exist and have been periodically sampled since early Archean times by magmas formed at depth and emplaced on the surface. These domains likely reflect re-enrichment of an originally niobium-depleted magma ocean through addition of extra-terrestrial chondritic material. We argue that the postulated enrichment process occurred during a giant impact after core formation, in a time window that coincides with the collision that is thought to have generated the Earth's Moon.

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HAFNIUM-NEODYNIUM ISOTOPIC DECOUPLING DURING THE FORMATION OF ARC PYROXENITES (CABO ORTEGAL COMPLEX, SPAIN)

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Petrological models accounting for the decoupling of Nd and Hf isotopes commonly invoke melt-peridotite interaction and ancient depletion. In the lower arc crust and sub-arc lithospheric mantle, melt-peridotite interaction and differentiation of primitive basaltic magmas are expected to produce abundant pyroxenites, which potentially can be recycled into the convective mantle. We here investigate the role of such pyroxenite-forming processes in the decoupling of Hf and Nd isotopes. In the Cabo Ortegal Complex, Spain, pyroxenites associated with dunites and harzburgites have been interpreted as a sub-arc mantle intruded by picritic/boninitic melts, and subsequently buried and exhumed during subduction, probably following delamination (Tilhac *et al.*, 2016). Petrological constraints also indicate that these pyroxenites experienced metamorphic, and potentially late-magmatic, amphibolitization. On this basis, we have applied Lu-Hf isotopic systematics to clinopyroxene, amphibole, and whole-rock samples of pyroxenites, and to associated peridotites, and Re-Os to whole-rock pyroxenites and chromitites. We show that, upon sub-solidus reactions under granulite- to amphibolite-facies conditions, amphibolitization only led to a slight Hf-isotopic disequilibrium between cpx and amphibole. In contrast to the relative robustness of the Lu-Hf system, the remobilization of Re is evidenced by correlations between amphibole abundance, LREE and the wide range of $^{187}Re/^{188}Os$, which resulted in $^{187}Os/^{188}Os$ between 0.16 and 1.44. The pyroxenites are characterized by uncorrelated $^{176}Lu/^{177}Hf$ and $^{176}Hf/^{177}Hf$, ascribed to the contribution of host peridotites during melt-peridotite interaction, and by strikingly decoupled age-corrected Nd- and Hf-isotope compositions ($\Delta\varepsilon_{Hf}$ up to + 139). This decoupling is interpreted as the result of interaction between HFSE-depleted melts and ancient SCLM, as supported by EMI-like Sr and Nd signatures (Tilhac *et al.*, 2017). In addition, we suggest that a relatively short distance of isotopic equilibrium (*ca* < 1m) arising from differential elemental and isotopic diffusivities during melt-peridotite interaction may be required to fully account for such decoupling. This is in agreement with the preservation within a 10 cm-thick sample of apparent Sm-Nd, Lu-Hf and Re-Os isochrons (459-1091 Ma), consistent with Re-depletion and Os model ages (588-950 Ma), indicating that the pyroxenites probably formed during a Cadomian event of arc magmatism.

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PETROGENESIS OF THE MANTLE BENEATH THE WEST BISMARCK ISLAND ARC

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Pristine peridotite xenoliths erupted from seamounts along the West Bismarck island arc provide a rare opportunity to investigate the chemical and physical manifestation of mantle modifying processes beneath active oceanic arcs. The sample suite consists dominantly of harzburgites along with subordinate dunites and pyroxenites. Significant textural variation is found within the harzburgite suite indicating a complex and spatially heterogeneous petrogenetic history. By combing textural observations with *in-situ* major element, trace element and water analyses, five significant petrogenetic stages were identified. The protolith formed through partial melting in a previously active arc, as indicated by high Mg# and Cr#, low Al_2O_2, very low concentrations of incompatible elements and an absence of residual clinopyroxene. Concentrations of Y and Yb in residual orthopyroxene require ~30 % of wet fractional melting of a depleted mantle source. A variety of metasomatic fluids subsequently refertilised the harzburgite residues with three chemically distinct populations of clinopyroxene, and created dunite and pyroxenite channels. The third stage was a period of sub-solidus cooling and chemical re-equilibration. The thermal history was quantified using a several geothermometers with different closure temperatures, revealing that cooling was both extensive (down to ~600 °C) but also very slow (~20 °C/My), consistent with the cooling rates of other subduction zone peridotites. The fourth stage marked the end of cooling and incorporation into the modern mantle wedge beneath the West Bismarck arc. Silicate melts interacted with the residual mantle through a network of veins, generating disequilibrium textures, most notably pyroxene-glass patches, accompanied by enrichment in trace elements and higher mineral-mineral temperatures. Finally, the samples were exhumed in host basalt, recorded in the late-stage diffusive loss of water from olivine. Modelling these diffusion p rofiles indicates the water-loss event lasted between 2-9 hours and was likely driven by shallow-level degassing of the host magma during ascent. The Ritter suite thus provides a remarkably detailed insight into the mechanisms through which modern sub-arc mantle is generated and modified. Many of these features appear characteristic of sub-arc mantle on a global scale, but also show similarities to cratonic mantle, indicating a potential genetic relationship between these two significant mantle domains.

FEEDBACKS BETWEEN DEFORMATION AND MELTS/FLUIDS IN THE UPPER MANTLE

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Experiments and theoretical considerations predict feedbacks between deformation and melts, namely strain localization controlled by the presence of melts and melt focusing controlled by deformation. Yet, peridotite massifs and mantle xenoliths, which record deformation and melt transport through the shallow mantle (lithosphere and lithosphere-asthenosphere boundary), feature a wide variety of relations between melts and deformation. These relations range from strong feedbacks between deformation and melt distribution to absence of any relation between the two processes. We will present an overview of the different types of relations between deformation and melts observed in the field (km to centimeter scale) and in thin sections (mm scale) and discuss some questions raised by these observations.

We will present, in particular, the results of recent petrostructural studies of the pargasite and phlogopite-bearing Finero peridotite massif (Italian Western Alps) and in mantle shear zones of Zabargad, which record the last stages of rifting in the Red Sea. The former observations (Tommasi et al., 2017) indicate that the presence of hydrous melts in a deforming peridotite allows for accommodation of large amounts of deformation by stress-controlled dissolution–precipitation and advective transport of matter by the melts and in fast grain boundary migration in olivine. It produces therefore significant rheological weakening in the upper mantle. However, this weakening is transient. Total crystallization or extraction of the melts is accompanied by a marked change in dominant deformation processes and strengthening of the peridotites, leading to onset of strain localization. The latter is not correlated to the local abundance in pargasite or phlogopite, implying that crystallization of amphiboles or phlogopite, even at concentrations of 25 vol.%, does not produce rheological weakening in the upper mantle. The petrostructural observations in the Zabargad peridotites point to progressive strain localization associated with decreasing temperature conditions and with a change in the composition of the percolating fluids, from melts to mantle derived fluids to sea-water contaminated aqueous fluids. These data indicate a strong control of the deformation on the fluids percolation, but there is no clear evidence for fluids controlling strain localization.

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GEOLOGICAL AND MINERALOGICAL STUDY OF TRAGANA OPHIOLITIC ROCKS, FTHIOTIS, GREECE

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Tragana's ophiolitic occurrence in Lokris, in the district of Fthiotis, in Greece, was geologically and petrologically studied. An attempt for its introduction to a greater scale geotectonic environment was carried out. The Tragana ophiolitic body is a tectonic slice emplaced onto the western margin of Pelagonian zone, mainly consisted of ultramafic rocks. Peridotites tectonically overlie an ophiolitic mélange that is characterized by a chaotic and heterogeneous mixture composed of rock fragments of spilites, altered gabbro, red chert and serpentinized peridotite. The ophiolite nappe is unconformably overlain by Upper-Cretaceous transgressive formations and Neogene sedimentary rocks. Samples were collected from the areas of Tragana and Kiparissi, in an attempt to create a catalog of the existing lithotypes. These are dunites, high-olivine harzburgites, high-clinopyroxene harzburgites, serpentinized harzburgites, serpentinites and basalts of the ophiolitic mélange. The samples were studied macroscopically and microscopically. The use of the microprobe allowed an analysis of the mineral chemistry in representing crystals of pyroxene, olivine and spinel. The orthopyroxene crystals consist of enstatite, while the clinopyroxene crystals consists of diopside. The olivines of the tectonized harzburgites are mostly Mg-rich forsterites. The spinels are homogenous and are classified in the field of Cr-spinels. The peridotites of Tragana fall within the olivine-spinel mantle array (OSMA) with a percentage around 10-20% of partial melting. The orthopyroxene-clinopyroxene geothermometer (920 ºC, 4,9kbar) and the corrected olivine-spinel geothermometer (755-807 ºC) were applied. Spinels of Tragana's ophiolitic rocks have been compared to those of other neighboring ophiolites. All areas show characteristics of abyssal peridotites in supra-subduction zones (SSZ) but differ greatly in their amounts of #Mg--#Cr and their percentage of partial melting. These differences are possibly due to an heterogeny in the upper mantle.

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CHARACTERIZATION OF THE METASOMATIC AGENT IN A COMPOSITE XENOLITH FROM MONT COUPET; FRENCH MASSIF CENTRAL (FRANCE): INSIGHTS FROM REDOX AND IN-SITU TRACE ELEMENT SIGNATURES

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A number of studies have demonstrated that the subcontinental lithospheric mantle (SCLM) underneath the French Massif Central has experienced variable degrees of metasomatism induced by percolating melt/fluids that has modified the geochemical and mineralogical composition, as well as the redox state [e.g. Lenoir et al.,2001; Downes et al., 2003; Uenver-Thiele et al., 2014]. The volcanic eruption at Mont Coupet sampled the underlying SCLM in form of sp-bearing harzburgites and lherzolites, which experienced cryptic and/or modal metasomatism as well [e.g. Uenver-Thiele et al., 2014; Uenver-Thiele et al., 2017; Gu et al., 2017]. Samples from this locality record oxidizing conditions with $\Delta\log f\mathrm{O}_2$ values ranging from FMQ+0.2 to FMQ+1.6, where FMQ is the fayalite–magnetite–quartz reference buffer [Downes et al., 2003]. At some localities, like Mont Coupet, composite mantle xenoliths can also be found. The aim of this study is to investigate the metasomatic processes/agents recorded in such a xenolith.

The composite xenolith is a spinel-bearing lherzolite (~15 cm diameter) containing a ~1cm thick cross-cut by a clinopyroxene-rich vein. In the protogranular matrix spinel occurs as a subordinate phase with either an irregular “holly leaf” form in sp-rich patches or as tiny interstitial grains. The modal amount of clinopyroxene is ~10% and significantly increases towards the vein (up to ~50%). Besides the modal addition of clinopyroxene, amphibole is homogeneously distributed in the matrix as small, dispersed interstitial grains.

Olivine has a uniform composition (X_{fo}= 0.90). The amphibole has a pargasitic composition with ~4 wt% Na_2O and ~3 wt% TiO_2. Clinopyroxene is Al-rich chromium diopsid with X_{Mg} = 0.93. Although clinopyroxene in the vein must be secondary, its major element composition does not differ significantly from grains in the matrix. The spinel has a Mg# and Cr# of 0.76 and 0.12-0.14, respectively. The Fe^{3+} content of spinel (determined using secondary spinel standards) exhibits a range of $Fe^{3+}/Fe_{\mathrm{tot}}$ from 0.14 to 0.20. The two-pyroxene temperatures (BKN) range from 750-950 °C with recording lower temperatures forwards the vein. In order to evaluate variations in redox state across the sample, oxygen fugacities (fO_2) were calculated using the Nell-Wood calibration for the olivine-orthopyroxene-spinel redox equilibrium [Wood et al., 1990]. Preliminary results yield $\Delta\log fO_2$ values between FMQ-0.8 and FMQ-1.3 with the lowest values recorded in the vein. This indicates that the clinopyroxene-forming melt/fluid was significantly reduced compared to ambient conditions in the Massif Central SCLM [Uenver-Thiele et al., 2014]. Trace element analysis by in situ LA-ICPMS on clinopyroxene and amphibole is underway to further evaluate the metasomatic agents that were responsible for the modal addition of amphibole and clinopyroxene, which must have been formed in a later stage.

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COMPOSITIONAL VARIATIONS OF PERIDOTITE XENOLITHS OF THE LOS TORMOS VOLCANO (CALATRAVA VOLCANIC FIELD, SPAIN)

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Los Tormos volcano (LTV) is one of the more than 200 volcanic vents (mainly scoria cone and maars) of the Neogene Calatrava volcanic field (CVF) in central Spain. The LTV is a scoria cone of olivine nephelinite pyroclasts, some of which include centimetre-sized peridotite xenoliths and scattered clinopyroxene megacrysts (up to 5 cm). The peridotite xenoliths show mainly coarse to medium grained protogranular texture, being mainly spinel lherzolites with minor wehrlite types. Lherzolite olivine and orthopyroxene have similar #Mg (0.87-0.91) and MnO (up to 0.25 wt%) composition. In contrast, olivine and clinopyroxene from wehrlites are similar to cores of both olivine and clinopyroxene phenocrysts of the host nephelinite (#Mg=0.83-0.87; NiO=0.05-0.39 wt%). Wehrlite clinopyroxene and megacrysts have also similar composition. Peridotite minerals are commonly rimmed by reaction zones and glass, which evidence pyrometamorphism while they were brought up to the surface by the ultra-alkaline magmas.

Clinopyroxene geobarometry and two pyroxenes geothermometry on lherzolites yield *P* about 10.5-15.3 kbar and *T* in the 960-1185 ºC range. Estimated pressure is similar to that obtained in clinopyroxene megacryst and microphenocryst cores (12-14 kbar). Estimates in phenocryst rims indicate a strong pressure decrease (2-9 kbar).

Lherzolite xenoliths have a nearly primitive mantle composition with low degrees of melting ($\leq$ 5%), similar to those estimate for other CVF peridotite samples (Villaseca et al., 2010), but slightly lower than those obtained according to pyroxene composition (up to 15%). Wehrlites with accessory amphibole (and phlogopite) evidence metasomatism. Amphibole usually appears rimmed by glass, clinopyroxene-2 and spinel-2. The more fertile composition of wehrlites indicates refertilization by a metasomatic agent probably derived from silica-undersaturated alkaline melts of the CVF.

We propose that CVF parental magmas stalled in spinel lherzolite upper mantle levels, where clinopyroxene and associated hydrous minerals (amphibole, phlogopite) crystallized (Dorado *et al.*, 2016). The later upwelling to shallower levels triggered the incorporation of mantle material along with a varied megacryst-phenocryst cargo from the crystallizing margin of the mantle magma chamber. Some of the lherzolite xenoliths, in addition to decompression, were strongly metasomatized by the ultra-alkaline magma, becoming wehrlite in composition.

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DOI:10.19276/plinius.2018.03015

PERIDOTITE XENOLITHS FROM MONTMATON, FRENCH MASSIF CENTRAL: FIRST OCCURRENCE OF Fe-Ti METASOMATISM

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The Tertiary-Quaternary age volcanism of the French Massif Central is well known for its numerous volcanic centers containing mantle-derived xenoliths. In spite of more than 100 years of scientific investigation, at least one locality has escaped scrutiny until now; Montmaton, located in the southern Aubrac volcanic field. This small exposure was discovered in the 1980's by Dr. Pierre Boivin, but remained uninvestigated until he passed his suite of samples on to us. Here, we present preliminary results of our petrologic study.

Five xenoliths have been investigated, all of which are lherzolites. Olivine compositions range from X_{Fo}=0.885-0.903, with very little variation within a given sample. Spinel compositions are Al-rich, with Cr# = 0.05-0.15. Fe^{3+} contents of spinel were measured by Mössbauer spectroscopy, giving $Fe^{3+}/\sum Fe$ of 0.22-0.33. Degrees of partial melting, based upon Cr# in spinel [Batanova V.G., Suhur G., Soboloev A.V., 1998] are low: F = 3-7 %. Two-pyroxene temperatures (BKN) range from 790-1020°C. Sample Mtm 5 stands out from the rest in that the olivine and orthopyroxene are relatively Fe-rich, clinopyroxene and orthopyroxene are Ti-rich. Amphibole is also present, representing a modal metasomatism and is kaersutitic containing 5.5 wt % TiO_2. To our knowledge this is the first occurrence of Fe-Ti metasomatism [Menzies, M.A., Hawksworth C.J., 1987] in the subcontinental lithospheric mantle (SCLM) beneath the Massif Central. Calculated $\Delta \log fO_2$ values are FMQ+0.2 – FMQ+0.8, which fall with in the range observed for the Massif Central as a whole [Uenver-Thiele L., Woodland A. B., Downes H., Altherr R., 2014]. Sample Mtm 5 records $\Delta \log fO_2$ = FMQ+0.5, indicating that Fe-Ti metasomatism is relatively high, but other types metasomatising agents can be even more oxidizing, similar to that observed at Lherz [Woodland AB, Kornprobst J, McPherson E, Bodinier J-L, Menzies MA, 1996].

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TOWARDS A COMPREHENSIVE INTERPRETATION OF THE EVOLUTION OF THE NORTHERN IVREA-VERBANO ZONE (FINERO COMPLEX, SOUTHERN ALPS)

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The Ivrea-Verbano Zone (IVZ, Southern Alps) is a well-known section of lower continental crust, where km-scale subcontinental mantle bodies crop out in proximity of the boundary of the Adria plate, represented by the Insubric line. Detailed mapping demonstrated that the mantle peridotites in the central IVZ were lenses tectonically interfingered with amphibolite to granulite-facies metamorphic rocks prior to the intrusion of the Upper Carboniferous-Lower Permian Mafic Complex, namely during the Variscan orogenic cycle or before, likely as part of an accretionary wedge (Quick et al., 1995).

Ongoing studies in the northernmost part of the IVZ (i.e. the Finero Complex) highlights further complexity. This domain is a tectonically-thinned section of the lower crust consisting of three tectonic units: 1) the structurally deepest unit has a lens shape and consists of the Phlogopite Peridotite mantle unit (PP), which is surrounded by mafic-ultramafic intrusive rocks of the Layered Internal Zone (LIZ) and by the Amphibole Peridotite (AP); 2) the intermediate unit (External Gabbro unit, EG) is made of deformed meta-gabbros/diorites and is bounded by ductile shear zones; 3) the shallower unit consists of amphibolites-facies basement rocks (Kinzigite Formation).

The PP mantle unit was pervasively metasomatised by peculiar K-LILE-rich melts with large crustal component and successively intruded by alkaline melts. The contact between the PP unit and the mafic intrusives is gradational and is characterized by a magmatic fabric in the mafic intrusives coherent with the solid-state deformation fabric of the peridotites. The LIZ and AP units record a large number of magmatic pulses related to both LREE-depleted and LREE-enriched melts, which were accompanied by variety of melt-rock reactions. As whole, the data suggest that the PP-LIZ/AP transition acted for a very long time as primary lithospheric discontinuity, representing a preferential level of channelling of uprising melts.

The U-Pb system of PP zircons records different thermal perturbations, which imply that the mantle sequence remained at high-T conditions until 190-180 Ma (Zanetti et al., 2016). The exhumation was driven by high-T shear zones, like those that form the tectonic boundary between AP and EG, during extensional stages that thinned the continental crust over an extended time interval (230-180 Ma; Langone et al., 2018). Later extension was focused westward, leading to the opening of the Jurassic Alpine Tethys.

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HIGH PRESSURE EXPERIMENTS ON THE ORIGIN OF MANTLE SOURCES FOR ULTRAPOTASSIC MAGMATISM

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Previous studies indicated that the high-K calk-alkaline, shoshonitic and lamproitic magmas typical for Mediterranean volcanism cannot be sourced within a normal four-phase mantle (Conticelli *et al.*, 2009). More viable is a vein-plus-wall-rock melting model, which involves a non-equilibrium melting reaction of metasomatic mineral assemblages (metasomes) with the surrounding mantle.

In our ongoing experimental study, we simulate a two-stage formation of ultrapotassic magmas: the first stage involves the reaction experiments containing layered sediment and lherzolite at 2GPa with the goal to produce a phlogopite-rich metasome as a consequence of sediment melt/mantle reaction; the second stage simulates the melting of the metasome resulting in melt infiltration and reaction with the surrounding mantle, with the ultimate goal to produce melts of ultrapotassic composition.

For the first stage, as a starting material, we use crustal lithologies that are different in terms of major and trace element compositions in order to localize the direct source for the metasome reactions. They include sediment ODP 201-1228 from the Pacific Ocean offshore from Peru, an allanite bearing gneiss and a lawsonite blueschist with unusually high Th/La ratios from the Tavşanlı zone, Turkey. In our first experimental stage, we started with the production of metasomes out of two-layer experiments in a piston-cylinder apparatus. Each starting material and harzburgite need to be charged in a two-layer capsule without being mixed.

These sandwich experiments are planned to be carried out at 2 GPa and 800 °C, 850 °C and 900 °C with run durations of two weeks. Each run will consist of three different capsules with different pairs of lithologies in a layered arrangement. In the second experimental stage, our plan is to extract the metasomatic reaction rim from the first-stage experiments and to use it for the follow- up experiments with a harzburgitic mantle source to produce the ultrapotassic melts which are expected to be of lamproitic composition. At the conference, we will present the first results from our experiments, including the major and trace element compositions of the metasome minerals from the first stage, as well as the infiltration melt compositions from the second stage experiments.

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MANTLE XENOLITHS FROM CENOZOIC LAVAS OF THE UPPER RHINE GRABEN: NIDDA (VOGELSBERG) CASE STUDY

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Vogelsberg (Central Germany) Cenozoic volcanic field is a part of CEVP, situated at the northern prolongation of the Upper Rhine Graben towards the Hessian Depression. NW part of the Vogelsberg is underlain by the Rheno-Hercynian Variscan basement, whereas the SE part is by that of Mid-German Crystalline High. Peridotite xenoliths from the Nidda basanite (Ehrenberg et al. 1982) provide information about lithospheric mantle beneath Mid-German Crystalline High. The Nidda xenoliths (3-8 cm in size) are clinopyroxene-poor spinel lherzolites and spinel harzburgites. They display protogranular, porphyroclastic and less commonly equigranular textures (sensu Mercier & Nicolas, 1975). Forsterite content in olivine defines two groups of xenoliths: A (Fo 90.4-91.5 %) and B (Fo ~89.5 %). Pyroxenes in both groups display high Mg# (0.894-0.925). Orthopyroxene from group A contains 0.10 to 0.23 atoms of Al pfu (per formula unit). Al content in clinopyroxene (0.09-0.28 atoms pfu) is negatively correlated with Mg#. Spinel displays Cr# ranging from 0.14 to 0.57 and Mg# from 0.65 to 0.85. The xenoliths of group B contain Al-rich (0.15-0.20 atoms pfu) orthopyroxene and clinopyroxene (0.20-0.27 atoms pfu). Spinel in group B peridotites has Cr# 0.21-0.22 and Mg# 0.77-0.80. All xenoliths fall in the OSMA field in the olivine Fo - spinel Cr# diagram (Arai, 1994). The group A clinopyroxene exhibits flat or LREE-depleted REE patterns, except for La and Ce which are enriched in some samples. Clinopyroxene of group B xenoliths is enriched in LREE relative to HREE. Orthopyroxene REE patterns show enrichment in HREE relative to LREE. Three different groups of peridotites are distinguished. The first one is characterized by Al-poor and relatively magnesian pyroxenes and spinel of high Cr#, suggesting partial melting and imprints of only slight metasomatism. The second group contains pyroxenes and spinel with high Al content and wider range of Mg#, which is lower than that in the first one, pointing out a main episode of metasomatism. The metasomatic agent was moderately alkaline, as indicated by mild LREE enrichment of clinopyroxenes. Supposedly, this metasomatism could correlate with the major stage of Vogelsberg Miocene volcanism described by Bogaard and Wörner (2003). The third group of xenoliths is intermediate between the two described above. Funding: This study was possible thanks to the project NCN UMO-2014/15/B/ST10/00095 of Polish National Centre for Science to JP.

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